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ABRIDGMENT OF

United States, British and German Patents

ON ALLOYS

Covering the Production

OF

**Platinum Substitutes Including
Alloys Having Certain of
the Properties of
Platinum**

MOCK & BLUM

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Compiled by
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New York, N. Y.



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GENERAL PREFACE

The purpose of this compilation is to provide in convenient form the accumulated technical experience of the world in providing alloys that may be used as substitutes for platinum. We have not confined this list literally to substitutes for platinum as we have included all alloys which are suitable for the manufacture of anti-corrosive and acid-resisting chemical ware which in many cases was hardly ever made of platinum on account of its costliness.

Experience shows that patents are applied for on nearly all valuable ideas and that the patents of the United States, Great Britain and Germany include practically all the important contributions to progress, because even if a valuable idea originates in some other country, it is ordinarily patented in one or more of those countries, because of their dominant industrial position.

As none of the Patent Offices of these countries have attempted to index or classify their patents for the particular purposes of this compilation, it is believed to be the first compilation of its kind.

Following the principal uses of platinum, we have classified the patents along the lines indicated in the general index and have prepared separate prefaces for each division of our work.

All United States patents more than seventeen years old, and all foreign patents which were not duplicated in this country are open to free public use. We have also included the characteristic claims of existing important United States patents so as to give an approximate idea of their scope.

Every effort has been made to include all pertinent matter and it is believed that a mine of valuable information is herein offered to the technical world.

Whenever an assignment of a United States Patent, still in force, appears on the face thereof, we have included this information.

MOCK & BLUM

New York, October, 1918.

HUGO MOCK.

ASHER BLUM.

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PREFACE TO CLASS 1

This class embraces those alloys which can replace platinum in the manufacture of articles extremely resistant to acids. In this class are included all alloys which resist the action of acids or corrosion and are applicable to articles which have hitherto not been made of platinum, such as valves and pumps, though they are in a sense platinum substitutes. There is a direct connection between this class and Class 3 in that the alloys which have extreme resistance to acids, also have a high resistance to oxidation, even at high temperatures. Thus, as is mentioned in German Patent #281,784, on page 271, the alloys which are almost completely resistant to oxidizing acids only require a small amount of platinum to make them suitable for apparatus which produces electric discharges or sparks.

The earlier U. S. patents ignore the properties of the metals of the chromium group.

Gesner patent #604,580 is very interesting as it depends upon an alloy of iron and hydrogen.

The Haynes patent #873,745 is the first U. S. patent still in force to use chromium.

U. S. patents #937,284 and #937,285 do not use chromium, but disclose a rather expensive alloy embodying a large amount of gold. U. S. patent #943,066 shows a cheap alloy comprising only manganese and nickel.

The British patents in this class largely correspond to the U. S. patents. However, they are interesting in that they show the use of chromium, tungsten, etc., for anti-acid alloys, long before the later U. S. patents. For example: British patent #1,923 of 1872, on page 98, shows a steel alloy having more than 30 per cent. of chromium, as well

as about 11½ per cent. of tungsten. No. 3,233 of 1884, on page 102, also shows the use of alloys containing chromium. The early U. S. patents such as #81,576 on page 73, also disclose alloys such as gold-silver, nickel-copper, or aluminium, or combinations of the above, on which additional patents were later taken out. In particular, U. S. patent. #573,615 shows the use of chromium for alloys intended to be resistant against acids and oxidation.

Valuable ideas are further disclosed by these expired patents, which are free to public use. Attention is also called to U. S. patent #1,236,384, which according to law is open to free public use by any person in this country.

It is believed that practically all the patents in Class 3 should be read in connection with this class, although every effort has been made to cross-index them properly

U. S. PATENTS

CLASS 1-A

100,397, Sibert, March 15, 1870

This alloy is composed of manganic steel, copper, zinc, and manganese.

To produce an alloy representing gold, I use one part of manganic steel, three-fourths part of copper, five-eighths part of zinc, and five-eighths part of powdered manganese.

To resemble silver, I take one part of manganic steel, one-sixteenth part of copper, seven-eighths part of zinc, and one-half part of powdered manganese.

Representations of other metals may be produced by varying the proportions. These alloys are not affected by the action of acids.

Common steel or iron first alloyed with manganese may be used instead of manganic steel.

In compounding, I take the molten iron or steel from the reducing-furnace into a receiver, and then mix in the copper, zinc, and manganese, keeping it well agitated. Silica may be used either in the reduction of the ore or in the receiver. Any of the carbonates, borax, or nitrate of potassa may be used as a flux.

397,699, Cowles et al., Feb. 12, 1889

This invention relates to metallic alloys and it consists in the combination of the metals hereinafter specified.

In carrying out our invention we take of:

	Parts
Copper	63,333
Nickel	33,333
Aluminium	3,333
	<hr/>
	99,999

These we fuse together in a crucible, so that they may be thoroughly mixed and alloyed.

In order to secure the best possible result and prevent the formation of oxides, powdered carbon or common salt may be spread over the metals in the crucible, so as to cover them and exclude the air. The resulting alloy is a new compound, which we have chosen to designate "Hercules metal" on account of its great strength, toughness, and resilience. This metal is the strongest known to the arts, and castings of it average over 100,000 pounds to the square inch in tensile strength, which is considerably more than the best grades of iron or steel.

The alloy when thus prepared and free from impurities compares favorably in hardness with the best tempered steel. It is also untarnishable, and is not affected by sulphur or acids to any appreciable extent.

604,580, *Gesner, May 24, 1888*

An alloy of iron and hydrogen is very stable and has extraordinary properties in resisting oxidation and corrosion. It is unaffected even by sulphuric acid or *aqua regia*.

Number 1 iron, or preferably scrap iron or steel at the highest temperature attainable, is introduced into a converter having a false bottom, and hydrogen is then blown up through the melted mass on the false bottom.

After this is done, jets of hydrogen and naphtha vapor are circulated through the molten mass, and then hydrogen is alone introduced until the flame at the top has a yellow color, which shows that the iron has ceased to absorb the hydrogen.

This alloy can be forged and rolled like wrought iron.

642,320, *Gesner, Jan. 30, 1900*

An alloy of iron and hydrogen is made by passing thin sheet iron through a furnace in an atmosphere of hydrogen. The temperature should be about 1800° F. The alloy is beaten off from the core of unalloyed iron, the scales of

alloy are heated to a temperature a little below that of ordinary melted iron, and the semi-liquid matter may be cast in sand or in solid moulds like iron or steel. The iron is also treated with naphtha vapors in the furnace, to carry away oxygen.

818,044, Parfitt, April 17, 1906

This relates to a compound which has improved non-oxidizing powers, and does not become affected in the presence of strong solutions of sulphuric acid and similar corrodents.

Iron is melted and decarbonized to contain as low a grade of carbon as possible without forming oxides, the body of molten metal not containing more than 0.1 per cent. of carbon.

To this 0.5 per cent. of aluminium and 0.3 per cent. of tungsten are added. Manganese, nickel, and tin may also be employed either separately or together.

I claim:

In the manufacture of metallic compounds, in which decarbonized iron is the basic or principal constituent, the process which consists in melting the iron, treating the latter so as to produce a resultant product containing not more than 0.1 per cent. of carbon, and adding to the metal metallic aluminium and metallic tungsten.

856,392, Chambaud, June 11, 1907

The object of this invention is a new aluminium alloy and the process employed in its manufacture.

Numerous alloys of aluminium are already known, but the alloy which is the subject of this invention is distinguished from those hitherto obtained by the nature and proportions of its constituent materials. These proportions are of considerable importance in that they give to the alloy particular and eminently characteristic qualities which are indicated below. The proportions of its constituent elements are as follows: Aluminium, 99.020 per

cent.; iron, 0.310 per cent.; zinc, 0.010 per cent.; magnesium, .041 per cent.; copper, 0.610 per cent. The remaining 0.009 per cent. is comprised of the silica which is found in the aluminium.

The new metal is a white silvery compound, of which the density does not exceed 2.7. It is very elastic, malleable and ductile, and more tenacious than copper. This metal beats out, embosses, hammers, bends, wire-draws, and welds very easily. It can be worked without the use of special tools. This alloy furthermore possesses great tensile strength and is not substantially oxidizable in air or water. It is particularly useful in cases where it is exposed to the action of sea water, which it has been found to successfully resist. In addition the new metal is not seriously attacked by any acid with the exception of hydrochloric acid.

To obtain the metal, the following process is employed: About 20 per cent. of the aluminium to be employed is first melted down in a suitable bath and when the temperature has reached about 750° C., the copper is added; when the fusion of this last metal is complete, the zinc is added and afterward the iron. After the complete fusion of this mixture the remaining 80 per cent. of the aluminium is added. The fluid mass is then withdrawn from the fire and the magnesium is incorporated with it.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. An aluminium alloy having the following proportions: Aluminium, about 99.020 per cent.; iron, 0.310 per cent.; zinc, 0.010 per cent.; magnesium, 0.041 per cent.; copper, 0.610 per cent., substantially as described.

2. The process of manufacture of aluminium alloy consisting in first melting about 20 per cent. of the aluminium to be employed, and when the temperature has reached about 750° C., in adding copper, and when the fusion of this last metal is complete in adding zinc, and afterward

iron, and after the complete fusion of this mixture, in adding the remaining 80 per cent. of the aluminium, and finally, in incorporating magnesium when the fluid mass is withdrawn from the fire as substantially described.

873,745, Haynes, Dec. 17, 1907

This invention relates to a novel metal alloy designed for use in the manufacture of articles requiring a high and durable luster, and possessing a degree of hardness adapting it to be substituted for mild tempered steel.

Among the objects of my invention is to produce a commercially practical metal alloy having the properties above set forth and which is capable of being forged, hammered or otherwise worked into various forms of instruments and articles, and which is highly adapted, among other uses, as a substitute for steel and other metals which have been heretofore plated in order to provide a suitable luster and resist the oxidizing and corrosive action of the atmosphere and fumes commonly occurring in the atmosphere; and also to provide an alloy that is capable of being substituted in many cases for the rare and highly expensive metals comprising the so-called polyxene group, including platinum, rhodium, irridium, palladium and osmium.

An alloy made in accordance with my invention is composed of chromium or other metal of the chromium group having properties like chromium, when considered with respect to the peculiar properties of my novel alloy, combined with cobalt in the proportions substantially as hereinafter specified. The metals included in the chromium group to which reference has been made embraces, in addition to chromium, tungsten, molybdenum and uranium. While I may employ other metals of the chromium group than chromium, my experiments up to the present time have led me to prefer the latter metal as possessing the most desirable qualities of a constituent of my alloy for the purposes and uses intended, though it may be found for different uses other metals of the chromium group may be used as a constituent of the alloy.

I have discovered that an alloy may be produced by fusing together chromium and cobalt, in the proportions substantially as hereinafter specified, having such properties as will enable it to receive an extremely lustrous polish, rivaling silver in this respect, and which is capable of resisting oxidation and all form of corrosive fumes commonly occurring in the atmosphere, and showing no tendency to tarnish when exposed to the atmosphere of a chemical laboratory for a long period of time, and even retaining its brilliantly polished surface when subjecting it to boiling nitric acid. By reason of these and other properties of the alloy it may be substituted for many of the metals of what is termed the polyxene group hereinbefore referred to. For example, my alloy may be used in the manufacture of standards of weight and measures and analogous purposes which have heretofore been made of platinum and irridium, with the result of possessing all the practical advantages of those metals at an immensely reduced cost to produce the same. I have also discovered, as an additional valuable property of this alloy, that it possesses a degree of hardness and elasticity which is fully equal to that of mild tempered steel and may be formed into edge tools having cutting qualities closely comparable to tools made of tempered steel. I have found that the alloy may be best worked into forms of utility when raised to the temperature of red heat.

In order that the alloy shall most advantageously possess the qualities above described, it is necessary that the constituent metals be substantially pure and especially that they shall be free from carbon, sulphur and like substances which seriously interfere with the non-tarnishing properties of the alloy. An alloy of chromium and cobalt which I have found to possess the aforesaid properties in varying degrees contains from 10 to 60 per cent. of chromium, together with a corresponding variation of cobalt. For instance, I have found that an alloy consisting of substantially 10 per cent. of chromium and 90 per cent. cobalt, is capable of taking a satisfactory cutting edge, is

hard while not brittle, but is not so resistive to corrosion as an alloy containing from 25 to 30 per cent. of chromium, while an alloy including the latter and somewhat higher proportions of chromium, are better suited to edged tools and like implements. I have found that pure carbonless chromium is very difficult to fuse, and the methods hereinafter referred to are the only ones of which I am aware that may be successfully practiced in the production of alloys containing more than 20 per cent. of chromium and ranging from that proportion to 60 per cent. Chromium containing a substantial percentage of carbon may be fused under lower temperatures, but the presence of the carbon is highly objectionable inasmuch as it does not take the high luster of the pure chromium alloy and is more readily tarnished. I desire it to be understood, however, that I may combine small quantities of other substances with the alloy described such as will not objectionably effect the nature of the binary alloy for the purposes stated.

I have produced the alloy of chromium and cobalt by three different methods or processes. One method or process consists in placing the pure metals, chromium and cobalt, in a magnesia crucible, which crucible is placed in a furnace lined with magnesia and the crucible heated by an oxyhydrogen flame. The metals may be fused in a crucible of similar character and construction heated by an electric arc. The third method of fusing the metals to alloy the same consists in mixing the oxide of chromium with the required proportion of oxide of cobalt and thereafter mixing these two oxides intimately with metallic aluminium preferably in the form of powder. Thereafter this mixture is introduced into a crucible lined with magnesia or alumina, and the mixture is either heated until decomposition takes place or is ignited cold and the metals are reduced to the metallic state and at the same time fused to a regulus by the extremely high temperature thus produced.

I claim as my invention :

1. A metal alloy composed of a metal of the chromium group and cobalt.
2. A metal alloy composed of cobalt and more than 10 per cent. of a metal of the chromium group.

873,746, Haynes, Dec. 17, 1907

This invention relates to a novel metal alloy designed for use in the manufacture of articles requiring a high and durable luster and enduring and permanent qualities, such as is required in metals from which are made standards of weight, measures, and like uses, and possessing a degree of hardness and elasticity adapting it to be used in the manufacture of tools and implements requiring a moderately sharp cutting edge.

Among the objects of my invention is to produce a commercially practical metal alloy having the properties above set forth and which is capable of being forged, hammered or otherwise worked into various forms of instruments and articles, and which is highly adapted, among other uses, as a substitute for metals which have been heretofore plated in order to provide a suitable luster and resist the oxidizing and corrosive action of the normal fumes of atmosphere and fumes of abnormal atmospheres occurring in chemical laboratories, manufacturing establishments and like places.

An alloy made in accordance with my invention is composed of chromium or other metal of the chromium group having properties like chromium, when considered with respect to the peculiar properties of my novel alloy, combined with nickel in the proportions substantially as hereinafter specified. The metals included in the chromium group to which reference has been made embraces, in addition to chromium, tungsten, molybdenum and uranium. While I may employ other metals of the chromium group than chromium, my experiments up to present time have led me to prefer the latter metal as possessing the most de-

sirable qualities of a constituent of my alloy for the purposes and uses intended, though it may be found for different uses other metals of the chromium group may be used as a constituent of the alloy.

I have discovered that an alloy may be produced by fusing together chromium and nickel, in the proportions substantially as hereinafter specified, having such properties as will enable it to receive a high lustrous polish and which is capable of resisting oxidation and all form of corrosive fumes commonly occurring in the atmosphere, and showing no tendency to tarnish when exposed to the atmosphere of a chemical laboratory for a long period of time, and even retaining its brilliantly polished surface when subjecting it to boiling nitric acid. I have also discovered, as an additional property of this alloy, that it is sufficiently hard and elastic to enable it to be used in the manufacture of tools and implements which require a moderately sharp edge and is also adaptable for various instruments used by surgeons, dentists and for many other uses where untarnishability is a requisite. I have found that the alloy may be best worked cold. My alloy is also capable of substitution for many of the rare and expensive metals of what is known as the polychrome group in the manufacture of standards of weight and measure and other articles and instruments for scientific uses demanding great durability and untarnishability.

In order that the alloy shall most advantageously possess the qualities above enumerated, it is necessary that the constituent metals be substantially pure and especially that they shall be free from carbon, sulphur and like substances which seriously interfere with the non-tarnishing properties of the alloy. An alloy of chromium and nickel which I have found to possess the aforesaid properties in varying degrees contains from 30 to 60 per cent. of chromium, together with a corresponding variation of the nickel. The addition of chromium above the lower percentage mentioned adds to the hardness of the alloy and also increases its resistance to tarnishability. I have

found that pure carbonless chromium is very difficult to fuse, and the methods hereinafter referred to are the only ones of which I am aware that may be successfully practiced in the production of alloys containing more than 30 per cent. of chromium and ranging from that proportion to 60 per cent. Chromium containing a substantial percentage of carbon may be fused under lower temperatures, but the presence of the carbon is highly objectionable inasmuch as it does not take the high luster of the pure chromium alloy and is more readily tarnished. I desire it to be understood, however, that I may combine small quantities of other substances with the alloy described such as will not objectionably affect the nature of the binary alloy for the purposes stated.

I have produced the alloy of chromium and nickel by three different methods or processes. One method or process consists in placing the pure metals, chromium and nickel, in a magnesia crucible, which crucible is placed in a furnace lined with magnesia and the crucible heated by an oxyhydrogen flame. The metals may be fused in a crucible of similar character and construction heated by an electric arc. The third method of fusing the metals to alloy the same consists in mixing the oxide of chromium with the required proportion of oxide of nickel and thereafter mixing these two oxides intimately with metallic aluminium preferably in the form of powder. Thereafter, this mixture is introduced into a crucible lined with magnesia or alumina, and the mixture is either heated until decomposition takes place or is ignited cold and the metals are reduced to the metallic state and at the same time fused to a regulus by the extremely high temperature thus produced.

I claim as my invention:

1. A metal alloy composed of nickel and more than 30 per cent. of a metal of the chromium group.

My invention relates to a composition of matter which is capable of extensive use for a great variety of purposes in many different arts. The primary object being, however, to provide valve disks, seats or packings in their nature somewhat elastic, and which will be indestructible upon contact of steam of any kind, oils, hot and cold water and the like, and other fluids of a destructive nature.

I prefer to use the following formula: 90 per cent. lead, 10 per cent. antimony. The lead used in my composition is of the ordinary kind, having a specific gravity of about 11.36 and an atomic weight of about 205.35; the antimony may be either amorphous or crystalline, and ordinarily has a specific gravity of 6.7 and an atomic weight of about 120. At this gravity and weight the antimony is easily fused with the lead.

For the purpose of obtaining a hard composition, for indestructible packing, and the like, to withstand the contact of steam, oils, acids, alkalies, and which will effectively resist the passage of fluids under high pressure, and will successfully withstand for a long period of time the action of such fluids, even though the temperature thereof may be high, that will be impervious to the attacks of the acids and alkalies, I have found it more advantageous to use 80 per cent. lead and 20 per cent. antimony. A composition possessing such high resistance qualities, is admirably adapted for a great variety of purposes and particularly for that of valve construction, conveying superheated steam under high pressure and temperatures that are employed in modern industries.

Having fully described my invention, what I claim as new, and desire to secure by Letters Patent, is:

1. A valve seat composed of an alloy containing lead and antimony, substantially as described.
2. A valve seat composed of an alloy containing 90 per cent. lead and 10 per cent. antimony, substantially as described.

This invention relates to the production of an alloy having certain valuable properties adapting it to a wide range of uses. It is heat refractory to an extraordinary degree and does not easily oxidize when subjected to a prolonged red heat in the atmosphere. It resists the action of moisture and is very acid proof, being insoluble in even concentrated mineral acids, boiling strong *aqua regia* being required for its solution. It has a high electrical resistivity, which adapts it well for electric heating and rheostat work since it withstands a red heat for a long continued service, and although under such conditions, it oxidizes slowly, the oxide is coherent and does not materially change its conductivity.

In the best composition I have thus far used, the alloy is composed approximately of

62 parts (by weight)	nickel,
20	" iron,
13	" chromium,
5	" manganese.

The manganese is present in a sufficiently large proportion to lend its properties as a metal, the amount being more than sufficient to aid in the formation of the alloy.

An alloy containing

62.040 parts (by weight)	nickel,
20.164	" iron,
12.630	" chromium,
4.910	" manganese,
.130	" silicon,
.040	" carbon,
.021	" phosphorus,

produces a metal capable of being rolled and drawn into extremely fine wire or ribbon having a resistivity of 117

microhms per cubic centimeter or seventy times that of pure copper. The alloy may be prepared in a powerful furnace, such as an oil furnace, and then worked in the ordinary way by rolling and drawing.

It will be understood, of course, that I do not limit my invention to the specific materials and proportions thereof herein set forth except in so far as it is limited by the scope of the claims annexed hereto.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An alloy containing iron, nickel, chromium and a manganese content exceeding 3 per cent., the iron content not exceeding 50 per cent.

2. An alloy containing iron, nickel, chromium, and a manganese content exceeding 3 per cent., the nickel being in excess of the other ingredients.

See U. S. Patent 926,980 on page 163.

See U. S. Patent 937,284 on page 165.

See U. S. Patent 937,285 on page 167.

See U. S. Patent 943,066 on page 169.

964,122, Rubel, July 12, 1910

The present invention relates to a new method of producing metal alloys—especially those composed chiefly of copper and zinc—containing elements of those metals such as chromium, manganese, tungsten and vanadium which has less affinity for chlorine than zinc has at the fusing temperature of the chloride of such metal. Such alloys are of high technical value and may be produced by this method at a relatively low cost.

The invention also relates to a compound to be used in the production of alloys of the character referred to. At the present time much difficulty is experienced, in the production of such alloys; and to alloy such metals as chromium, manganese, tungsten or vanadium with copper and zinc, has been found very difficult.

In carrying out my invention I first form a compound of the particular metal with zinc and then melt the alloy thus formed with the copper or other metal.

The first compound is obtained by melting a chloride of the particular metal with a proper proportion of zinc. For example, to produce an alloy containing chromium, chromium chloride in the proper proportion to produce the desired percentage of chromium in the final alloy is melted with zinc and the chromium liberated is alloyed in a nascent state with the zinc present in excess. The chromium-zinc compound thus produced is melted with an amount of copper or other metal proportional to the percentage of chromium desired. For example, to produce 100 kgs. of chromium-bronze, 3.2 kgs. of chromium chloride may be alloyed with 40 kgs. of zinc. The chromium-zinc compound thus obtained is added to 57 kgs. of copper. For a manganese-bronze 2.5 kgs. of manganese chloride (MnCl_2) may be melted with the zinc and this compound may be added to a proportionate amount of copper. The particular proportions may, however, be varied within wide limits according to the desired percentage of the chromium or manganese desired in the final alloy. Thus to produce 4 per cent. of chromium or manganese in the bronze the chromium chloride would be increased to 10 kgs. and the manganese chloride to 12.8 kgs. These amounts, it will be understood, are for producing 100 kgs. of the final zinc-copper alloy.

Under this process chlorides may be added up to 5 per cent. of the metal containing the chloride without requiring heating above the melting point of the copper.

An alloy produced by this process and containing 1 per cent. of chromium or manganese, fifty-eight parts of copper and forty parts of zinc, has a strength of 58 kilos. with a limit of elasticity of 29 kilos., and extensibility of from 18 to 20 per cent. An addition of about 2 per cent. of aluminium will greatly accelerate the reduction of the chlorides. In thus compounding the zinc with the chlorides of the manganese, chromium, or other metal, chloride of zinc is produced and this is of special advantage.

In casting all alloys containing a certain quantity of zinc, oxide of zinc is produced and this forms accumulations and frequently produces loose, spongy places in the walls of the casting. The chloride of zinc that is produced in my process dissolves this oxide of zinc, so that much better castings are obtained.

As chlorides of chromium, manganese and tungsten are very inexpensive compared with the pure metals, the alloys containing those metals can be produced by my process at much less expense than has heretofore been possible. The alloys of chromium and manganese are especially important. They present great strength at ordinary temperatures, and do not lose their strength when heated to a high temperature. The chromium alloys also exhibit great resistance to chemical agents, because the chromium is reduced from a chloride and is alloyed *in statu nascendi* with the zinc; it is hardly attacked by such agents as sulphuric, nitric and hydrochloric acids. Copper-zinc alloys containing chromium and manganese when produced by present methods do not have this power of resistance to the action of chemicals, because the chromium or manganese reduced in accordance with the Goldschmidt process or with carbon do not possess any neutrality to acids.

What I claim is as follows:

1. The process of producing alloys which consists in first forming a compound of zinc and a chloride of a metal having a less affinity for chlorine than zinc has at the fusing temperature of such chloride, and then melting said zinc chloride compound with another metal.

1,019,963, Jacquier, March 12, 1912

This invention relates to a new or improved alloy or metallic compound which is capable of resisting the corrosive action of sulphuric acid, cyanide solution, etc.

The alloy can be used for the manufacture of pipes, tanks, taps, valves, screens, cables, ropes, skeps, cages and similar vehicles, pumps and other machinery or appli-

ances used in mining or other industries which it is desirable to protect from the corrosive action of liquids with which they come in contact. The articles which it is desired to render acid resistant can be made entirely of my improved alloy, or can be suitably coated or lined either internally or externally or both with the alloy.

My improved alloy or metallic compound is composed of aluminium, bismuth, copper and silicon or magnesium which are used in the following proportions, more or less: aluminium, 92 per cent.; bismuth, 2 per cent.; copper, 5 per cent.; silicon, 1 per cent., or aluminium, 91 per cent.; bismuth, 2 per cent.; copper, 5 per cent.; magnesium, 2 per cent.

In manufacturing the alloy the bismuth, copper and silicon or magnesium are placed in a crucible and melted together, and to the resultant alloy, while still molten, is added the aluminium, which has previously been melted.

By suitably varying the proportions of the ingredients the degree of hardness and other properties of the product can be varied.

What I claim as my invention and desire to protect by Letters Patent is:

1. An anti-corrosive alloy or metallic compound consisting of aluminium, bismuth, copper and silicon, as set forth.

2. An anti-corrosive alloy or metallic compound consisting of approximately 92 per cent. of aluminium, 2 per cent. of bismuth, 5 per cent. of copper, and 1 per cent. of silicon, as set forth.

*1,043,579, Eldred (Assigned to Commercial Research Co.),
Nov. 5, 1912*

This relates to a crucible or other chemical vessel of platinum, gold or other noble metal having cored walls containing a reinforcing core layer of a ferrous metal

welded to the surrounding noble metal and hermetically sealed in thereby.

The platinum or similar noble metal are united to form a compound billet as indicated in U. S. Patents Nos. 1,043,577-1,043,578, etc., and this billet is rolled, etc., to form sheets from which complete articles may be stamped out or otherwise formed. It is preferable to stamp or spin the sheet metal. A dish so stamped or spun will present an exposed edge of steel or iron at its mouth where the compound plate has been cut. This exposed edge is covered by drawing or working the noble metal from the two sides until the two sides contact, and then subjecting this contacting line to an intense heat until an autogenous union is formed. A core of pure iron is preferred.

I claim:

1. A chemical crucible comprising a surface of a layer of a noble metal and a core layer of ferrous metal completely enveloped and hermetically sealed in by such surface layer, said surface layer being welded to said ferrous metal.

1,057,828, Elwood Haynes, April 1, 1913

This invention relates to a metal alloy more particularly designed for use in the manufacture of articles, such as tools or cutting implements, wherein are required the qualities of hardness, toughness and elasticity, together with the capacity of taking a high polish and receiving and retaining a sharp cutting edge.

In my prior Patent No. 873,745, issued December 17, 1907, I have described a binary alloy, consisting of cobalt and chromium, or other metal of the chromium group allied with chromium, or having properties like those of chromium; such metals of the chromium group embracing, in addition to chromium, tungsten, molybdenum and uranium. The binary alloy described in said patent possesses a high degree of hardness and toughness adapting it for use in the manufacture of edged tools, cutlery

and the like, has a high degree of resistance to oxidization and the corrosive action of the atmosphere and fumes occurring therein, and is capable of being forged, hammered, or otherwise worked into various forms of instruments and articles.

I have discovered that quaternary alloys, consisting of cobalt and three metals of the chromium group, possess particular value and qualities in many respects superior to those of the binary alloy set forth in said patent above mentioned. I have discovered, moreover, that such quaternary alloys possess very valuable properties when composed of cobalt, chromium, tungsten and molybdenum.

An alloy made in accordance with my invention is composed of cobalt, chromium and two of the other metals of the chromium group, combined in the proportions substantially as hereinafter specified. The metals included in the chromium group, to which reference has been made, embrace, in addition to chromium, tungsten, molybdenum and uranium. My experiments up to the present time have led me to prefer, of the metals of the chromium group, tungsten and molybdenum, as possessing the most desirable qualities as constituents of my alloy for the general purposes and uses intended, although it may be found that for different uses the other metal of the chromium group, to wit, uranium, may be employed to advantage, as one of the constituents of the alloy. An alloy of cobalt, chromium, tungsten and molybdenum, which I have found to possess the desired properties for many articles or uses, contains chromium in a percentage of 15 per cent. or less, and tungsten and molybdenum together in a percentage of 15 per cent. or less. Such quaternary alloys may be readily forged at a red heat. Moreover, by using a considerable amount of care an alloy containing 65 per cent. of cobalt, 15 per cent. of chromium and 20 per cent. of tungsten and molybdenum can be forged to a considerable degree. All such quaternary alloys possess valuable properties in addition to those of the binary, or cobalt and chromium alloys, for many purposes, on account of the

tungsten and molybdenum constituents, which give to the alloy increased hardness and toughness, as well as a superior capacity to receive a sharp cutting edge and to retain the same under the most severe usage.

In a quaternary alloy of cobalt, chromium, tungsten and molybdenum, if the chromium constituent equals 25 per cent. and the tungsten and molybdenum together be present in the proportion of 5 per cent., the alloy is particularly suitable for wood-cutting tools, table knives and other cutlery. Such an alloy forges readily, shows a fine fracture, is very strong and elastic, and takes a fine cutting edge. Moreover, this alloy possesses the desirable qualities of the cobalt-chromium alloy described in my prior Patent No. 873,745 in being capable of taking a high and durable luster, and of resisting the oxidizing and corrosive fumes commonly occurring in the atmosphere.

If in a quaternary alloy of cobalt, chromium, tungsten and molybdenum, the tungsten and molybdenum constituents together be increased from 15 per cent. to say, 50 per cent., the alloy becomes harder with increasing percentage of tungsten and molybdenum, and the same cannot be successfully forged after the last named constituents exceed 25 per cent. A quaternary alloy containing from 25 per cent. to 50 per cent. of tungsten and molybdenum, and 15 per cent. of chromium, the remainder being cobalt, makes excellent lathe tools, possessing to a high degree the qualities of hardness, toughness and capacity of receiving and retaining a very sharp cutting edge. I have found that such lathe tools possess hardness, toughness and cutting qualities to a degree making them much superior to any steel lathe tools now produced. Moreover, such alloy is found to be capable of resisting to a large degree the corrosive action of moisture and the atmosphere. When the tungsten and molybdenum constituents together exceed 25 per cent., the alloy becomes sufficiently hard to readily scratch glass, and will even mark or score rock crystal. When the tungsten and molybdenum constituents taken together, are present in percentages of 25 to 50 per cent.

of the total, the quaternary alloy, while not capable of being forged, may be readily fused, and lathe tools or other articles may be readily made by casting the same in the desired form and finishing by a suitable grinding operation. When the tungsten and molybdenum constituents in the quaternary alloy together exceed 50 per cent., the alloy becomes very difficult to fuse, or fuses under very high temperatures, such as are usually obtainable only by the use of the electric arc, but the alloy containing such higher percentages of these metals, while somewhat brittle, makes excellent lathe tools.

In the quaternary alloys containing both molybdenum and tungsten, the same general conditions and characteristics are found to exist with varying proportions of these constituents; excepting that the increase in the percentage of molybdenum has a greater effect than an increase in the tungsten constituent, in lessening the capacity of the alloy to undergo the operation of forging. If the molybdenum constituent in such alloy exceeds 25 per cent., the alloy is made very hard, and if the proportion of molybdenum does not exceed 30 per cent. and the proportion of tungsten is relatively small, the alloy is not only very hard but likewise very tough and strong, and may be used with great advantage for lathe tools. When the percentage of molybdenum is as high as 40 per cent. or more, the alloy becomes exceedingly hard and quite brittle. It will cut persistently into glass, and a sharp corner of the metal, when drawn back and forth over the surface of a quartz crystal, will rapidly cut a deep groove in that material.

In the quaternary alloys of cobalt, chromium, tungsten and molybdenum, an increase in the percentage of the chromium constituent will give greater hardness and brittleness to these alloys, even when they contain the tungsten and molybdenum in the lower percentages. I have found, however, that the alloys described, possess considerable toughness when the chromium constituent is present to the extent of as much as 40 per cent., and if the tungsten and molybdenum constituents be low, that alloys

useful for practical purposes may contain even a higher percentage of chromium. In view of the fact, however, that an increase of the percentage, either of the chromium constituent, or of the tungsten and molybdenum constituents tends to render the alloy more brittle, a smaller proportionate quantity of chromium will desirably be used when the proportion of tungsten and molybdenum is relatively large and vice versa. This is indicated by the examples above given of quaternary alloys suitable in one instance for cutlery and the like, and the other instance, for lathe tools; to wit, in the first instance, 25 per cent. of chromium and 5 per cent. of tungsten and molybdenum with a corresponding percentage of the cobalt constituent, and, in the second instance, 15 per cent. of chromium, and 25 per cent. of tungsten and molybdenum with a corresponding percentage of cobalt.

The quaternary alloy consisting of cobalt, chromium, and two of the other metals of the chromium group, namely, both tungsten and molybdenum, are particularly suitable for high speed lathe tools. For example, I have produced an alloy containing 5 per cent. of molybdenum, 25 per cent. of tungsten, 15 per cent. of chromium and 55 per cent. of cobalt, which, after being cast into a bar and made into a lathe tool, affords a tool which will cut cast iron or steel, without overheating of or injury to the tool, from 50 to 100 per cent. faster than a tool made from the best special or "high speed" steel now produced for such purposes. In the case of such quaternary alloys, the chromium constituent may be present in the proportion of from 5 to 60 per cent., or the tungsten and molybdenum constituents together may be present in the same proportions of from 5 to 60 per cent. with such relative proportions of the chromium constituent, on the one hand, and the total quantity of the tungsten and molybdenum constituents, on the other hand, as to prevent an undesirable degree of brittleness in the alloy.

I have found, in general, that cobalt, in an alloy with three or more metals of the chromium group, produces a

series of useful alloys, throughout a very wide range in the relative proportion of the constituents. In the case of admixtures of many other metals, the hardness rapidly increases with the increase in the proportion of one or more of the constituents, until the alloy becomes so brittle as to be unfit for practical use. As, for instance, if copper be alloyed with tin, an increase in the hardness of the alloy takes place, until, when the proportion of tin is materially over 10 per cent., the alloy becomes so brittle as to be unfit for practical use. To the contrary, an increase in either the chromium constituent, or the tungsten and molybdenum constituents in the quaternary alloys referred to, even beyond the proportions hereinbefore generally stated (but so far as my experiments have gone, not exactly determined), will not make the alloy too brittle for practical uses. In other words, my tests have shown that, when the constituents of the alloys described are present, within the wide range of relative proportions stated, a series of alloys may be produced having novel and very valuable properties, and capable of use in the arts with great advantage and benefit.

It is to be understood that small quantities of other metals, or non-metallic substances, may be combined with the quaternary alloys described, such as will not injuriously affect the nature of such alloys, and which may to some extent modify their properties and render them more suitable for special requirements.

From the above, it will be understood that I have discovered new and useful quaternary metal alloys, consisting of cobalt, chromium and two other metals of the chromium group, and that these combinations or alloys possess peculiar and novel characteristics. It is also to be understood that any other metal of the chromium group may be added to the alloy or substituted in the alloy for either one of the metals of the chromium group hereinbefore particularly specified.

I claim as my invention :

1. A metal alloy composed of cobalt, chromium and two other metals of the chromium group.

2. A metal alloy composed of cobalt, chromium, tungsten and molybdenum.

See U. S. Patent 1,093,557 on page 125.

See U. S. Patent 1,096,655 on page 187.

See U. S. Patent 1,101,534 on page 188.

1,110,303, Hans Kreusler (Assigned to General Electric Company), Sept. 8, 1914

The present invention relates to alloys of tungsten and other highly refractory metals related to it, particularly molybdenum.

More particularly, the invention relates to alloys of these metals with nickel. These alloys have on the one hand a very high percentage of tungsten, molybdenum and the like, and on the other hand the property of being very ductile, so that they can be drawn out into very fine wires. Further, these alloys having a small percentage of nickel have the property that the nickel can be completely removed from them again without it being necessary to fuse them. In addition, the alloys with a high percentage of tungsten and a small percentage of nickel resist the action of acids and other chemical materials in a particularly high degree, so that in many respects they behave like a precious metal.

All these properties accrue to the mentioned alloys only when the percentage of nickel is not less than about 1 per cent. and when the percentage of the metal of the tungsten-molybdenum group is not less than about 60 per cent. If the percentage of tungsten is less than the amount mentioned, it is found, for example, that it is no longer possible to drive off the nickel electrically *in vacuo* without the alloy fusing. If the percentage of nickel is less than 1 per cent., the alloy is not sufficiently ductile. Even with

4½ per cent. of nickel the ductility of the alloy is still very slight, and only with about 5 per cent. and more are alloys obtained which correspond to the highest requirements which can be demanded.

Alloys consisting of 85 to 95 per cent. of tungsten and 15 to 5 per cent. of nickel, particularly alloys of 90 per cent. tungsten and 10 per cent. nickel, prove to be of very special utility, but a part of the nickel may be replaced by iron or other metals. For example, an alloy consisting of 90 per cent. tungsten, with 5 per cent. nickel and 5 per cent. iron, is found to be very good.

The tungsten may also be wholly or partially replaced by other highly refractory metals, particularly by those of the tungsten-molybdenum group, such as chromium, tungsten and molybdenum.

The finely drawn wires of such alloys are of special technical importance in the art of making electric incandescent lamps, because they possess great mechanical resistance; they can, therefore, be easily manufactured into filaments, which then are attached to the electrodes and placed in a highly rarefied atmosphere or in a vacuum, and are then heated in such manner by passing through them an electric current that the total quantity of nickel is driven out again, so that a pure tungsten filament is finally obtained. This method is described in more detail hereinafter.

In order to make alloys of tungsten or of another metal related to it with nickel, which have only a small percentage of nickel and which are ductile, the following method is preferably employed: The metal of the tungsten-molybdenum group and the highly refractory metals which, in addition, are possibly to be incorporated in it, are united with nickel to form a uniform homogeneous metallic mass at as low a temperature as possible, and in any event at a temperature below the melting point of the metal of the tungsten-molybdenum group. In order to do this, tungsten and nickel may, for example, be mixed in an exceedingly finely divided state with one another and be made plastic with the aid of a suitable agglutinant, for example

paraffin. As small a quantity as possible of the agglutinant is employed. The plastic mass is brought into the form of a small rod and is then gradually heated until the agglutinant is removed again and the metallic powders are baked together, forming a rod of sufficient mechanical strength. This rod is then heated further until a quite homogeneous and ductile metallic mass is produced, which, however, still maintains the form of the original small rod.

A specially suitable agglutinant is a colloidal solution of a tungsten compound which can be reduced completely to tungsten by hydrogen, for example colloidal tungstic acid, or still better a colloidal plastic mass of tungsten compounds made by heating dry tungstate of ammonia to about 270° C. and then boiling the mass in water, such as is described in the American Patent No. 956,979, filed June 22, 1907. When such an agglutinant is employed, tungsten and nickel in the finest pulverized form, or, instead of them, still better, an oxide of tungsten and nickel monoxide are mixed with the reducible plastic mass of tungsten compounds which serves as agglutinant, and a small rod is made from the mass thus obtained. This small rod may have a length, for example, of from 20 cms. to 30 cms. and a diameter of 1 to 2 mm. for example. The rod dries easily and is then very firm, and is placed in an electric furnace, which consists of an electrically heated pipe or tube. The latter may consist, for example, of carbon with a lining of nickel or other material of very great stability in heat, quartz being particularly suitable.

When a rod of the desired ductility is obtained, it can be shaped mechanically by rolling, drawing, hammering and the like. A wire consisting, for example, of 7 to 20 per cent. nickel and 93 to 80 per cent. tungsten, which has been obtained in the above described manner, may, for example, be drawn out into the very finest wires, such as are able to be used for the manufacture of metallic filaments for electric incandescent lamps and for many other purposes.

If a body obtained by mechanically working up such an alloy be placed in a very highly rarefied atmosphere, for example, in the receiver of an air pump, and if it be heated by passing through it an electric current, the temperature being gradually increased without it rising to the melting point of the alloy, however, the nickel contained in the body is vaporized again, without the body changing in shape. A body of tungsten, possessing the original shape and having a correspondingly smaller percentage of nickel, remains behind, or also a pure tungsten body, when the vaporizing process is continued for a correspondingly long time. In this manner it is possible to make solid bodies of tungsten without having recourse to a fusing process. This method can be put into practice, particularly easily, with wires which are drawn from the alloy. The ends of the wires are connected to the leads connected with a suitable source of electric current, and the entire wire is placed in the receiver of an air pump, whereupon the air is exhausted until a vacuum exists, and the wire is heated to red heat by sending through it a current, whereupon by gradually increasing the strength of the current the temperature is increased in such manner that the nickel begins to vaporize. When the method is continued for a sufficiently long time a filament is obtained which is perfectly free from nickel and which is excellently suited as a filament for electric incandescent lamps.

For the latter purpose the wire is first brought into the shape suitable for the incandescent lamp, is attached to electrodes, and hereupon is liberated from the nickel by passing through it an electric current. The wire is then placed in the lamp-bulb, whereupon the latter is exhausted and sealed in the manner usual in the manufacture of electric incandescent lamps.

What I claim as my invention and desire to secure by Letters Patent is:

1. A metallic alloy containing more than 60 per cent. of metal of the tungsten-molybdenum group and more than 1 per cent. of nickel, and having the property of ductility.

2. A metallic alloy containing 95 per cent. to 75 per cent. of tungsten, not more than 15 per cent. of nickel and not more than 10 per cent. of another metal, and having the property of ductility.

1,115,239, Parr, Oct. 27, 1914

Bomb calorimeters as ordinarily used are constructed of steel, with the inner faces lined with platinum or with gold-plated copper, to resist the corrosive action of the nitric acid liberated in the calorimeter when in use. Such constructions have the disadvantage of high cost, and also the disadvantage that moisture may work in under the lining and subsequently impair the accuracy of the heat determination. Also platinum linings as thus used within a calorimeter are easily damaged and are otherwise objectionable, as is well known.

As the result of extended experiment and investigation, I have discovered a new alloy which is so resistant to the corrosive action of the moist oxygen, or of ordinary acids, such as nitric acid, that it can be used within the calorimeter and exposed directly to the action of the calorimeter charge. The alloy is so resistant that it may be used for valve seats, and similar parts of apparatus where the wear and exposure are extreme, without appreciable corrosion or deterioration even after long continued use. This alloy is also adapted for use in the construction of chemical vessels, and as electric resistance wire and as a substitute for platinum and other expensive materials, and in the form of a wire or sheet metal suitably shaped and worked, may be used in a great variety of ways, where its special characteristics make it of special value in the technical arts. In general, this new alloy comprises nickel as its basis, together with a certain amount of chromium or of molybdenum, or of both, and a somewhat smaller quantity of copper. The chromium increases the melting temperature and also leads to brittleness. The copper, on the other hand, tends to lower the melting point, but it cannot be used except in moderate

quantity, without lowering the resistance to corrosion. I have found that there is also advantage in having tungsten present, and while its presence may not be necessary, yet it tends toward easy casting and also strengthens the acid resisting properties of the alloy. Molybdenum may be used in place of tungsten to a very considerable extent with some resultant advantages. Tungsten is much like chromium in promoting resistance to acid attack, but it is quite in contrast with chromium in that it permits easy casting and reduces shrinkage. Aluminium and manganese in small quantities can also be used to advantage, being added after the mass is fluid and when it is about in condition for pouring. Aluminium lowers the melting point of the alloy somewhat and besides being a good deoxidizer, it accentuates the resistance to both nitric and sulphuric acid. Manganese serves much as aluminium. Titanium and boron in fractional percentages may also be used.

I have found that the relative proportion of the elements above named may be varied through relatively wide limits and still yield an alloy having, in the main, the mechanical strength and toughness and the acid resisting characteristics of metal suitable for use in calorimeters, and as electrical resistances, and in the arts generally. I have found that the following composition, by weight, gives good results: 63 parts nickel; 5 parts copper; 15 parts chromium; 10 parts of molybdenum-chromium alloy in equal percentages; 2 parts tungsten; $1\frac{1}{2}$ parts aluminium; $1\frac{1}{2}$ parts manganese-titanium alloy compounded in the proportions of 70 parts manganese to 30 parts titanium; 1 part manganese-boron alloy compounded in the proportion 70 parts manganese to 30 parts boron; 1 part copper-silicon alloy compounded in the proportions 80 parts copper to 20 parts silicon; $\frac{1}{2}$ part boron suboxide (approximately $B_{15}O$). As to variations from the above proportions, I have found that the nickel content may vary between 55 and 65 per cent., and the copper between 5 and 11 per cent. As to the members of the chromium group, viz., chromium, molybdenum and tungsten, these metals are to some extent

interchangeable, but preferably should total in the neighborhood of 27 per cent. Molybdenum, in its behavior, seems more pronounced than tungsten in promoting resistivity to acid, and may vary from 5 to 8 per cent. The chromium content may vary between 15 and 21 per cent., the tungsten between about 2 and 3 per cent., and the aluminium between $\frac{1}{2}$ and $1\frac{1}{2}$ per cent. The manganese and titanium may be omitted altogether, although I regard them as substantial aids in casting and as desirable deoxidizers. The boron and boron suboxide can also be omitted, their principal functions being that of a flux and degasifier, but if any boron remains behind in the alloy, it offers no disadvantage and may even present some advantages. Silicon also may be omitted.

In practice I prefer to melt together in about the proportion above indicated, the nickel, chromium, molybdenum-chromium alloy, copper and tungsten, and then after the melt is fluid, I add the aluminium, manganese-titanium alloy, manganese-boron alloy and copper-silicon alloy in about the proportions stated, these additions serving to remove gases and increase the fluidity of the melt and otherwise assisting in bringing the material into better physical and chemical condition for pouring. Finally, I add the $\frac{1}{2}$ per cent. suboxide, and this acts to eliminate absorbed gases and to deoxidize the other metals.

In some melts I have omitted both the copper-silicon alloy and the boron flux and still obtained a satisfactory product, and I am aware that the manganese may be omitted and that various changes may be made in the admixtures of the aluminium, manganese, titanium and boron, without greatly influencing the final result, though the proportions above indicated are, at the present time, considered by me as most satisfactory in obtaining uniformly good results. The boron, besides acting as a deoxidizer, appears to act as a mixer. Some carbon may be present to the extent of $\frac{1}{10}$ of 1 per cent., and my research indicates that the carbon has some virtue in helping

to resist the solvent action of acid. Some iron may be present without harm, say 1/10 of 1 per cent.

The best melting and casting temperature for the alloy here disclosed, in its various modifications, is in the neighborhood of 1300° C., with 1500° C. as the upper limit.

The alloy may be cast in iron moulds not heated, or in sand, and when thus made has a tensile strength of about 55,000 to 60,000 pounds per square inch. The cast material can be rolled and drawn into wire and can be spun and mechanically worked according to well known metal working methods. With drawn wire, the tensile strength is much greater than that given for the cast material, being in the neighborhood of 124,000 pounds per square inch in some cases. The relatively great strength and toughness of the alloy even in cast condition is of importance, when the material is used in the construction of calorimeters, because the pressure developed within the calorimeters may be as high as 1,000 pounds per square inch, even under normal conditions. Also this great strength and toughness makes the alloy suited for use in the mechanical arts, in a great many ways, where a corrosion resistant material is essential. The electrical resistance of the alloy is high, being in the neighborhood of fifty times that of copper. The melting point is in the neighborhood of 1200° to 1300° C.

The material, either in cast, rolled or drawn condition, is non-oxidizable in the ordinary sense. Corrosion, if it occurs at all, at atmospheric temperature and pressure, when 100 square centimeters area is subjected for twenty-four hours to four times normal HNO_3 or H_2SO_4 , or mixtures of these acids, is so slight as to be substantially within the experimental error of weighing, even though the balance used may show changes of one-tenth of a milligram. Samples of about 10 square centimeter area have been exposed for as long as ten days to 25 per cent. nitric acid, with no loss in weight which could be detected by the most accurate weighing. With other samples under the same conditions, there was a loss of .002 milligrams per

100 square centimeters per hour in 25 per cent. nitric acid, and for practical purposes this may be regarded as no corrosion.

The alloy is equally insoluble in 25 per cent. H_2SO_4 or in a 25 per cent. mixture of two parts sulphuric acid to one part nitric acid. In 25 per cent. hydrochloric acid, the corrosion is possibly twice as high as in nitric (for such samples as show any corrosion in nitric), and consequently even with hydrochloric, the material may be said to be non-corrosive.

As the result of the continued use of the alloy here disclosed, for exposed surfaces in a bomb calorimeter of the construction disclosed in my application above identified, where the alloy is directly in contact with the hot gases, it may be said that the total corrosion within the bomb, under the extreme temperatures and pressures there encountered, need not exceed five-tenths of a milligram for each heat, and such a slight corrosion, assuming that it might take place, would introduce a variable of not more than 1 part in 10,000, which of course, is well within the experimental accuracy of methods for using bomb calorimeters.

In addition to the use of this alloy for bomb calorimeters and for valves; valve seats and exposed portions of chemical vessels, it has a wide range of uses in the electrical and mechanical arts where its special characteristics of relative great strength and toughness, high electrical resistance and more particularly its resistance to oxidation or corrosion, can be made use of.

I claim:

1. A non-oxidizing alloy having a composition of about 63 parts nickel, 5 parts copper, 20 parts chromium, 5 parts molybdenum, and 2 parts tungsten.

2. A non-oxidizing alloy consisting of approximately 63 parts nickel, 5 parts copper, 20 parts chromium, 5 parts molybdenum, 2 parts tungsten, and a small percentage of deoxidizing material substantially as described.

This invention relates to noble alloys; and it comprises as a new and useful composition of matter an alloy of noble characteristics containing cobalt and chromium together with iron as a third or softening metal; such alloy containing no substantial amounts, say, not over 4 or 5 per cent. of other metals and containing little carbon; all as more fully hereinafter set forth and as claimed.

In composition with various other metals, chromium alloys can be obtained which are noble in their characteristics; that is, they resemble the noble metals, such as gold and silver, in that they do not suffer alteration or change in their surfaces by exposure to acids, oxidizing influences, air, etc. In certain prior patents I have described and claimed a number of alloys of this character. In one such patent, No. 873,945, I have described and claimed an alloy consisting substantially of cobalt and chromium. These alloys of chromium with cobalt offer a high resistance against atmospheric influences. Such an alloy containing 10 per cent. or more of cobalt resists boiling with nitric acid and many other extreme oxidizing actions. It does not tarnish and can be given a pleasing and permanent polish. The alloy can be worked while hot and can be given a good and permanent edge; and in edge tools the metal is sufficiently hard to enable it to cut most other metals. As a rule the hardness increases with the amount of chromium present. These alloys, however, are somewhat difficult to work, the difficulty increasing with the amount of chromium present. They can, however, be cast into ingots or bars and these bars worked at high temperatures by special manipulation, but this working is somewhat costly because of the high temperatures required. Their hardness is also greater than is required in actual use in making knives, auger bits, gimlets, etc. It is sufficient for most of the purposes of edge tools if the metal used is sufficiently hard to cut wood, bone and materials of like nature, though for some purposes, of course, an even greater hardness is desirable. For these latter

purposes I have described and claimed in various patents, alloys of this character having the hardness enhanced by an addition of other metals of the chromium group. But, as stated, for certain purposes so much hardness as is found in chromium-cobalt alloys is not necessary; and is even disadvantageous. For example, in a wood saw there is no use of more hardness than suffices for cutting wood, and great hardness of metal not only makes the production of the saw more expensive and difficult, but adds to the labor and trouble of renewing the sharpness of the tool after long use. The cobalt-chromium alloys are so hard as to make filing difficult, and grinding tedious and laborious. I have found, however, that without sacrifice of their valuable properties, as regards resistance to oxidizing influence, these alloys can be somewhat softened by an addition of iron. This diminution of hardness may be to any degree desired. Nickel in a chromium-cobalt alloy has some of the softening influence of iron, but not in so marked a degree, and the iron-containing alloys are tougher, both hot and cold, and are therefore easier to work. These ternary cobalt-chromium-iron alloys are of sufficient hardness to serve efficiently for saws and similar tools; being as hard or harder than the ordinary tempered steel employed for such purposes, but not so hard as to prevent ready re-sharpening with a file or grindstone. A similar alloy containing nickel, replacing part or all of the iron in a cobalt-chromium-iron alloy, has some of the same advantages. As noted, however, the softening influence of nickel in such alloys is not as great as that of iron. A series of alloys of cobalt, chromium and iron, with low carbon content, has been prepared, containing a constant per cent. of chromium (about 20 per cent.), in which the iron content has been gradually increased from 10 per cent. to 75 per cent. of the entire mixture. Alloys so formed show little variation in either their chemical or physical properties so long as they contain 5 per cent. or more of cobalt and from 20 per cent. to 25 per cent. of chromium. They are all readily malleable at a bright, red

heat and can be worked into sheets or rods from cast ingots without difficulty. These alloys receive and retain a beautiful luster and are much less subject to oxidation or other changes in the atmosphere than the binary alloys, consisting of iron and chromium alloy. Such alloys containing a constant percentage of chromium (namely, 20 per cent.) and varying from 5 per cent. to 75 per cent. in iron (at intervals of 10 per cent.) and varying in the proportion of cobalt from 70 per cent. to 5 per cent., made in the form of bars, were ground to a smooth surface and then covered with a strong solution of ammonium chloride which was allowed to dry on. The bars were then subjected to moist air for several days, but failed to show the slightest stain or tarnish. While these ternary alloys are distinctly softer than the alloys of cobalt and chromium only, they have certain peculiar advantages which give them wide application, for example, such alloys may be manufactured into saws, boring tools, etc., which possess sufficient hardness for wood-working tools of this description; and at the same time these tools can be worked almost as readily by the file as similar instruments made of steel. These ternary alloys also work very well under hammer at a moderate red heat. The softening influence of the iron is so great that the per cent. of chromium may be quite high. In an alloy containing a given amount of chromium, the cobalt and iron have opposite influences, the cobalt tending to harden, and the iron to soften. An alloy containing, say, 40 per cent. chromium, 20 per cent. iron and 40 per cent. cobalt, is much more workable than an alloy containing 40 per cent. chromium and 60 per cent. cobalt. In these alloys it is desirable not to have any material amount of carbon; say, not above 1 per cent. carbon; while a carbon content below 0.60 is better. Alloys containing as little as 0.2 to 0.4 per cent. are even better. Carbon makes the alloy more fusible, but it detracts from its properties for the purposes here intended.

An alloy of 55 parts iron, 25 parts cobalt and 20 parts chromium is highly resistant against atmospheric influ-

ence, works readily under the hammer at a red heat and is, considering ordinary steels, very hard; but it is nevertheless soft enough to permit slow filing with an ordinary file. Tools of this alloy are hard enough to permit easy working of wood, bone, ivory and soft metals, and are easily sharpened at ordinary temperatures.

The present alloys have inherent hardness; their hardness is not much affected by working or temperature changes. Tempering has little effect. The presence of carbon changes their properties in this respect. By adding carbon to these ternary alloys they may be hardened to a considerable degree without losing very much in malleability, and for certain purposes carbon may become a valuable constituent. Silicon, sulphur, etc., should be substantially absent.

For some purposes a slight addition of other metals of the chromium group may be made to the ternary alloys here described, though these elements tend to harden the alloy and make it less workable. But the amount of such an addition should ordinarily not exceed, say, 4 or 5 per cent. For example, 2 or 3 per cent. of molybdenum may be added to an iron-cobalt-chromium alloy to give it a somewhat different surface appearance or color. For some purposes such an addition is advantageous.

The described alloys may be made by melting together the required amounts of the several metals. Alumina or magnesia crucibles are most suitable as being highly refractory and containing no carbon. Graphite crucibles should not be used without a lining of indifferent material since otherwise they tend to raise the carbon content. Any convenient manner of heating, such as the oxyhydrogen or oxy-acetylene flame, electric heating, etc., may be used. With high amounts of chromium, electric heating is better. Ferro-chromium may be employed in making these alloys, but on account of its high carbon content, it is necessary to remove the excess of carbon in some way. This may be done by adding to the melt a small amount of oxide of chromium, oxide of iron or oxide of cobalt, proper allow-

ance being, of course, made in the composition for the amount of metal thus reduced. A little ferro-titanium may be added to the melt for the purposes of removing oxygen and nitrogen, etc. Or a little manganese may be used as a deoxidant. After fusion, the alloy may be cast into ingots or bars of any suitable size or shape—five-sixteenths square bars are convenient for many purposes. The bar so produced may be worked down to tools at a red heat, by hammering, rolling, swaging, etc. Knife blades, saws, etc., may be given their shape and edge during the working. The edge will be retained on cooling. Drilling, grinding and polishing are easily practicable in the manufacture of tools without need of using very hard abrasives, such as carborundum.

The relative ratios of the three metals may be as desired for the particular purposes desired. An increase in the amount of chromium raises the melting point, the hardness and the resistance to oxidation, and the cobalt tends in the same direction, while an increase in the amount of iron (or, in a less degree, of nickel) renders the alloy more fusible, more malleable and softer. In securing noble alloys having the characteristics desired in the present invention, there should always be a substantial amount, say, 10 per cent. or more, of chromium present; and the same is true of the other two metals. An alloy may be made of 10 per cent. chromium and 90 per cent. of cobalt and iron together, which is excellent for some purposes, but it is much better to have between 20 and 30 per cent. of chromium. Alloys running as high as 80 per cent. chromium may be made, but are hard to melt and work. Ten per cent. of iron will soften cobalt-chromium alloys considerably, but 20 to 30 per cent. is better. To obtain the full value of these alloys, particularly as regards their resistance to atmospheric influences or corrosive agents, they should contain as high as 10 per cent. chromium. The chromium may be increased to 40 or 50 per cent. if desired for certain purposes, but these higher percentages render the alloy much less workable under the hammer.

Alloys containing from 20 to 30 per cent. chromium are preferable for most purposes.

What I claim is:

1. As a new material, a noble alloy of cobalt, chromium and iron.
2. As a new material, a noble alloy of cobalt, chromium and iron, said iron being present in amounts greater than 10 per cent.
3. As a new material, a noble alloy of cobalt, chromium and iron, said cobalt being present in amount greater than 5 per cent.

See U. S. Patent 1,162,341 on page 306.

See U. S. Patent 1,169,753 on page 277.

*1,203,555, Brix (Assigned to American Alloys Company),
Oct. 31, 1916*

My invention relates to alloys.

The alloy, which is the subject matter of my invention, has several highly valuable characteristics, and in its preferred form it may be designated as a nickel-chrome alloy, since the nickel-chrome content predominates.

I have found that an alloy comprising predominantly nickel or cobalt, the nickel or cobalt content being, say, not less than about 55 per cent. by weight, and one or more metals of the chromium group, such as chromium or chromium and tungsten, or chromium and titanium, between 13 and 35 per cent., with silicon not over 10 per cent., which have been melted with one or more metals, such as copper and manganese, to give fluidity to the alloy and render it homogeneous, has very valuable characteristics.

The preferred form of the alloy, by actual test, has been found to stand a very high degree of heat—about 3000° F., and to be dissolved only by hot aqua regia (nitrohydrochloric acid). In its preferred form it is substantially,

if not entirely, unaffected by other acids, thus rendering it highly valuable for use in making laboratory utensils, or other articles, which must withstand a high temperature or be substantially unaffected by ordinary acids. I have also found that the alloy is hard and capable of taking a good edge and may be made malleable, and on account of these features it is highly useful for cutlery, tools and instruments generally. The alloy in some forms is also ductile.

I will first state the ingredients of the preferred form of the alloy, giving the relative proportions of each for the preferred form of the alloy, and their functions in the alloy. I will then point out, by way of example, some substitute ingredients that I have found to be satisfactory, and will then describe the preferred method of making the preferred form of the alloy, and will then particularly point out my invention in the appended claims.

The preferred form of the alloy contains nickel, chromium, copper, silicon, tungsten, aluminium and manganese (the aluminium appearing as a result of the manufacture of the alloy, as aluminium facilitates the manufacture, but it is mostly burned out and may be replaced by copper in producing or manufacturing even the preferred form of alloy, although for some uses of the alloy the presence of aluminium in the alloy may prove to give to it certain desirable features). This form of the alloy is made by reducing to a molten mass the following metals, in the approximate proportions set forth: Nickel, 60 to 70 per cent., by weight; chromium, 15 to 20 per cent., by weight; copper, 5 per cent., by weight; silicon, 4 per cent., by weight; tungsten, 1 to 4 per cent., by weight; aluminium, 2 per cent., by weight; manganese-titanium (two-thirds manganese), 3 per cent., by weight, or manganese, 2 per cent., by weight, and boron 1 per cent., by weight. I have found that an alloy made from these metals in substantially the proportions given, has the valuable characteristics of the alloy heretofore mentioned. The nickel and chromium are the main ingredients which, with the tung-

sten and the use of boron or titanium in the manufacture of the alloy, give the metal its high melting point, which may be varied by varying the proportions of tungsten and boron. Increase in the proportion of tungsten with the use of boron as a flux increases the melting point of the alloy. The silicon and chromium are the most important constituents giving the acid-resisting quality to the alloy. Silicon and tungsten give the alloy its property of hardness. When relatively small percentages of silicon and chromium are used, the alloy, as stated, is ductile and malleable. I have found that the temperature at which the alloy is poured regulates to a marked extent its ductility and malleability, and that the proportions of the nickel and chromium also affect these characteristics; an increase of nickel and a reduction of chromium increases the malleability and ductility, and vice versa.

I have found that for some uses of the alloy cobalt may be substituted for the nickel, but when such a substitution is made the alloy is not so acid-resisting, as it will not withstand hydrochloric acid. I have also found that for some uses of the alloy, another suitable metal of the tungsten group, such as titanium, may be substituted for the tungsten ingredient of the preferred form of the alloy. With this substitution the alloy is homogeneous and ductile, and withstands the ordinary acids, but is lacking in hardness. I have also found that inasmuch as copper and aluminium are used principally to assist in the melting of the alloy and to give it its homogeneous character, the aluminium content may be replaced by an equivalent amount of copper or other suitable metal of low melting point having the same effect on the contents of the alloy as copper. In such a case it is preferable to substitute for the aluminium substantially the same amount of copper in addition to that usually used with the aluminium. The result of such substitution seems to give no marked or different characteristic than when both copper and aluminium are used, but the use of aluminium with the copper is preferable from the standpoint of manufacture, since

it facilitates the melting of the metals. Some of the copper and a considerable amount of the aluminium are burned out in the manufacture of the alloy; and where the small amount of titanium is used with the manganese, very little, if any, titanium seems to be retained in the alloy; but where titanium is substituted for tungsten, as above stated, of course a very appreciable percentage remains in the alloy. I have also found that the respective ingredients of the contents may be varied for the purpose of changing the characteristics of the alloy in one or another particular. As far as I have been able to ascertain, the nickel or cobalt content should be between 55 and 80 per cent., by weight; chromium, between 10 and 25 per cent., by weight; copper, not over 6 per cent., by weight; aluminium, not over 4 per cent., by weight; tungsten or titanium, not over 8 per cent., by weight; silicon, not over 10 per cent., by weight; manganese, not over 6 per cent., by weight, and titanium or boron when used as a flux with manganese, not over 5 per cent., by weight; and the combined nickel and chromium content or cobalt-chromium content should not exceed 90 per cent., by weight. It will, of course, be understood, however, that rapid strides are being made in the manufacture of alloys, both in the process of melting the constituents and in rolling or forging the alloys, and that with these improved methods of manufacture it is possible that the respective ingredients of the alloy may be further varied while retaining certain valuable characteristics thereof.

By way of illustrating the manner in which the characteristics of the alloy are affected by varying the different ingredients, I will give a few examples of the alloy in which the percentages of certain ingredients were varied. For example, the alloy made from nickel, 61 per cent.; chromium, 20 per cent.; copper, 5 per cent.; aluminium, 3 per cent.; tungsten, 4 per cent.; silicon, 4 per cent., and manganese-titanium (two-thirds manganese), 3 per cent., produced an alloy which was very hard, substantially resistant to all acids other than nitro-hydrochloric acid and

which took a good edge and was somewhat malleable. Whereas, an alloy made from nickel, 72 per cent.; chromium, 16 per cent.; copper, 4 per cent.; aluminium, 1 per cent.; silicon, 4 per cent., and manganese-titanium (two-thirds manganese), 3 per cent., retains its acid-resisting property, but is very ductile and capable of being rolled and drawn into wire; and an alloy made with nickel, 68 per cent.; chromium, 15 per cent.; silicon, 8 per cent.; copper, 4 per cent.; tungsten, 1 per cent.; aluminium, 1 per cent., and manganese-titanium (two-thirds manganese), 3 per cent., has the characteristic of great hardness, but is less ductile than alloy example No. 2. The alloy made with nickel, 65 per cent.; chromium, 22 per cent.; silicon, 4 per cent., and the rest of the ingredients as given in the last example (No. 3), was not as hard as the alloy No. 3, but was harder than the alloy No. 2, and had marked acid-resisting properties.

In manufacturing the alloy according to the preferred method, I place the whole of the tungsten and half of the chromium in an electric furnace, the temperature of which is approximately 2800° to 3400° F., and heat them until the mixture comes to a semi-molten or pasty consistency, whereupon the other half of the chromium is placed in the furnace and the whole is melted. As the compound in the electric furnace is brought to the melting point, and just before it is melted, so as to assist in melting it, a small percentage—for example, about 5 per cent. of the nickel is added, and the whole thoroughly melted. Simultaneously with the melting of these metals in the electric furnace, the balance of the nickel, the copper and the silicon are placed in another furnace such, for example, as a gas furnace, the temperature of which is approximately 2800° F., and melted. While the compound in the gas furnace is being brought to the melting point, the aluminium is gradually added in small quantities. The addition of the aluminium in this manner acts effectively as a reducing agent on the other metals in the furnace, combining with the oxides, and, I believe, more particularly with the oxides of

the copper to assist in reducing the same. When the constituents in both furnaces have been melted, the contents of the gas furnace are emptied into the electric furnace and the whole stirred, whereupon the manganese and titanium or manganese and boron are added to the whole and stirred, the heat being kept up until the entire mixture is thoroughly melted, the time for which I find in practice to consume about five minutes from the time the manganese was added. The different contents are all used in the metallic form. The manganese and titanium or manganese and boron act as a flux, assisting in melting the alloy, these metals being deoxidizing agents, acting to clarify the solution and aiding in the melting of the metals. I believe that the titanium combines with the oxygen from the other metals, or with the oxides and sulphides, which latter are present as impurities in one or more of the constituents, and thus aids in reducing these metals and purifying the alloy. The manganese not only acts as a flux and reducing agent, but as a constituent in the alloy. The boron or titanium, however, either of which may be used as a flux with the manganese, seem to completely disappear in the process of melting the alloy, since so far I have been unable to find any traces of them in the resulting product. Their use, however, in the manufacture of the product plays a highly important part, since I have found that the alloy made without them is of a coarser and less homogeneous structure. I have also found that some of the aluminium is volatilized or otherwise disappears during the melting operation, although a perceptible amount of it remains in the alloy. In melting the alloy, such fluxes as Paris green and niter, and other well known fluxes, may be made use of, to assist in reducing the metals. I have found that an alloy made according to the above process and containing the above ingredients in substantially the proportions set forth, is soluble in hot aquaregia (nitro-hydrochloric acid) and is slightly affected by cold aquaregia, although not soluble therein, but is substantially unaffected by the ordinary acids.

The alloy may be made into knives or surgical instruments, and has been found to take and hold a sharp edge.

The alloy can be used in laboratory and other uses where receptacles or other articles are required having acid-resisting qualities and capable of standing high temperatures.

Where, in the specification, I use the expression, "one or more metals of the nickel group, such as nickel," I do not wish to be understood as meaning any other metals of this group than nickel or cobalt. They are the only two metals, as far as I now know, that have sufficiently like characteristics to render them suitable for the main constituent of the alloy according to my invention, and I use this expression for lack of any better term that would include both of these metals; and where I use, in the appended claims, the word "nickel," as distinguished from the above-mentioned expression, I wish to be understood as meaning nickel, to the exclusion of cobalt; also, where I use the expression, in the appended claims, "non-ferrous metal alloy," I mean an alloy containing substantially no iron; that is, no iron in substantial amounts, such as would change the characteristics of the alloys, and where, in the appended claims, I refer to the percentages of the different ingredients, I wish to be understood as meaning percentages by weight.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. A metal alloy containing one or more metals of the nickel group, such as nickel not under 55 per cent., one or more metals of the chromium group, such as chromium, not over 30 per cent., and one or more metals that will act on the contents of the alloy to assist in melting the same and to render the alloy homogeneous, such as copper and manganese.

2. A non-ferrous metal alloy containing one or more metals of the nickel group, such as nickel from 60 to 80

per cent., one or more metals of the chromium group, such as chromium over 10 per cent. and less than 25 per cent., said constituents having been alloyed by the use of one or more metals, such as copper and manganese, to assist in melting the same and render the alloy homogeneous.

3. A non-ferrous metal alloy containing one or more metals of the nickel group, such as nickel not under 60 per cent., one or more metals of the chromium group, such as chromium over 10 per cent. and less than 25 per cent., and in addition, tungsten; said constituents having been alloyed by the use of one or more metals, such as copper and manganese, to assist in melting the same and render the alloy homogeneous.

See U. S. Patent 1,221,769 on page 205.

1,229,960, Humphries (Assigned to Commercial Research Company), June 12, 1917

This invention relates to metal articles, especially an article of hard, dense metal, composed mainly of tungsten group metal and a smaller percentage of the class of nickel, cobalt, iron or the like. The metals to be united are first produced in the form of fine-grained powders, and the mixture is heated in a plurality of temperature stages, with a pause at each stage, until a hard, dense and malleable material of high conductivity is produced.

Metallic material for use as contact points or elements ordinarily have the form of a rivet-like element secured in an orificed holding member and they are usually composed of assembled bodies of different metals, because of the necessity of different metallic qualities. The contact-making surface must be non-oxidizing, hard, and permanent. The body of the element must be mechanically strong and hard to secure it to the holder, and should be capable of being riveted into place.

The best contact elements are now made by uniting a facing layer of platinum to a shank of nickel.

This invention produces a material from which noble-surfaced rivetable contact points can be made, and which is also applicable to many other purposes requiring incorrodible acid-proof, strong metal, as tooth pins, commutator segments, jewelry, anodes, etc. This is made of tungsten and a metal of the iron class of which nickel is much the best. The proportion of tungsten is preferably 85 to 95 per cent. For some purpose it is advantageous to have some molybdenum. This method herein disclosed may be applied to the manufacture of molybdenum articles containing small proportions of tungsten or no tungsten. A small proportion, say 0.5 to 3 per cent. of molybdenum, makes a material of even more noble characteristics than tungsten alone.

The material can be swaged and worked to produce bodies of compact metal which can be headed up or riveted into place.

Fine powdered tungsten of cryptocrystalline or semi-amorphous character is used. This should be sufficiently fine to pass through a 200-mesh sieve, but not be completely impalpable or colloid. The best material is dark gray and free from perceptible brownish spots or hue. The material may have a slight brownish cast, but is best not distinctly brown. It is best not coarsely crystalline. It need not be perfectly pure, a certain amount of impurities indeed appearing to facilitate the operation. It may be made by reduction from commercial tungstic oxide (or tungstic acid) by hydrogen. The oxide may contain about 0.2 per cent. of alkalis and about the same amount of phosphoric acid. This can be reduced by hydrogen in a furnace, care being taken that the temperature rises quite slowly and that the metal remains amorphous without becoming coarse and crystalline. A small amount of oxygen is left in the material.

This tungsten is mixed with finely divided nickel, which may be also obtained by a similar reduction, as of nickel oxide or oxalate at a low temperature. The temperature in reduction should not rise quickly enough to make the

metal coarse grained. It should be amorphous and as fine grained as possible. The nickel should be completely impalpable. Metal produced from the oxalate is finer than that from the oxide. The reduction may be performed at about 300° C., and some oxygen is allowed to remain, not over 2 per cent. This powder is often pyrophoric.

These two metals are now mixed. A mixture of 85 to 95 per cent. tungsten, and 15 to 5 per cent. of nickel is useful. A material of 6 to 8 per cent. is suitable for contact points. A little more nickel (say a few tenths per cent) than is desired in the final material is used, to allow for losses by volatilization.

The mixed metals are now pressed into bars or slabs, a solution of camphor in ether being used as a temporary binder. A bar of square cross-section, $\frac{1}{4}$ inch on the side and 8 inches long, may be made from 85 gms. of the mixture, and this size is desirable in the process.

This bar is sintered in a hydrogen atmosphere. Heating, which may be by fire heat, should be gradual to prevent disruption by volatilization or carbonization of the binder. The best temperature is 800 to 1100° C., and the treatment may be for 10 minutes. The slug is then allowed to cool in a non-oxidizing atmosphere; when it will have a light gray color and present the appearance of a hard, coked mass. It is then exceedingly brittle.

The slug is now heated in a plurality of temperature stages, with a pause at each stage, in an atmosphere of hydrogen, by passing a current through the slug. The first heating should be to about 1200° C., for about 5 minutes. This eliminates the impurities and the oxygen.

The temperature is again raised, to about 1400° C. The mass now shrinks considerably. The heating is in a hydrogen atmosphere, for about 5 minutes.

The shrunk billet is now heated to about 1600° C., at which temperature nickel is freely fluid, for about 5 minutes. This produces a hard, dense body, which may be swaged or rolled, becoming more compact, tenacious, and

hard with each working. Either hot or cold swaging may be resorted to, and annealing may be employed.

In hot swaging, the slug may be reheated to 1200°-1500° C., 1400° C. being the best for a material containing 6 to 8 per cent. of nickel. It is then worked at about 5,000 blows per minute, being reheated at intervals. As the operation progresses, the temperature may drop and the speed of the swaging machine may be increased to 7,000 blows per minute. In making contact elements, the slug may be reduced to a round body of 0.16 to 0.125 inch. Pieces of this round body or rod may be given a shank by an emery or carborundum wheel.

This shank may be upset or headed with a prick punch. A wafer or disk of the metal may be welded to a shank of another metal to give a composite element.

The slug may be cold swaged, being annealed after each three or five passes, or after a reduction of 0.025 inch in diameter.

A material with 6 to 8 per cent. nickel has a higher melting point than platinum and suffers little erosion, when used for electrical purposes. It is extremely acid resistant, making it suitable for toothpins, anodes, etc.

Iron or cobalt may be used instead of nickel, in whole or in part.

I claim:

1. As a new material, a hard, dense, relatively conductive, mechanically homogeneous fine-grained metallic mass, mainly composed of particles of a metal of the tungsten class, but also containing another and bonding metal of lower melting point, said mass being substantially non-ductile, but malleable to an extent which will permit swaging hot or cold.

2. In the manufacture of tungsten materials, the process which comprises mixing a finely-grained metal of the tungsten class with another metal of lower melting point, heating the mixture to a temperature at which said

other metal is freely fluid and holding at this temperature sufficiently long to permit a limited degree of interpenetration without complete alloying of the two metals.

1,236,384, Fahrenwald, Aug. 7, 1917

(This patent may be used free by any person in the United States.)

This invention relates to a composition of matter containing tungsten and molybdenum, together with the process of making the same. Owing to the extremely elevated melting points of these materials it has so far been impossible to alloy either with the other or with any other substance by the usual fusion methods. The present invention relates to the method of incorporating these two metals together, without the necessity for fusion, and subsequently, by repeated mechanical working under predetermined temperature and metallographic conditions, to reduce the composition to such a state of malleability, ductility and tensile strength as shall fit it for use in the arts.

My researches have shown that the strength and ductility of these metals depends upon the fostering of an amorphous condition therein as against a crystalline condition.

With tungsten and molybdenum and gold, the amorphous condition is produced most quickly and in the largest possible degree when the cold working of the metal is commenced at the lowest practicable temperature, although this temperature will vary, depending upon the violence of the mechanical forces to which the mass is subjected. Thus, if metallic crystalline tungsten is merely forged by hammering between comparatively flat surfaces, the metal will preserve its integrity at a considerably lower temperature than if it be swaged, rolled, drawn or otherwise more vigorously distorted.

The maximum amorphous condition is secured in most uniform measure, when the structure of the tungsten metal at the beginning of the mechanical cold-working consists of a uniform formation of comparatively fine crystals, and

this can be secured with pure tungsten, pure molybdenum, and with alloys of the two, in any desired proportion, by suitable heat treatment of the material just prior to the beginning of the cold-working. In the case of both of these metals, the reduction temperature is far less than the fusion temperature, wherefore, the metallic substances are originally obtained in the form of amorphous powders. These powders, either pure, or mixed in any desired proportion, are compacted into briquets under a pressure of about 200,000 pounds. With a tungsten briquet of this nature, the most satisfactory crystalline condition is obtained when the material was subjected for about 10 minutes to a temperature of about 2600° C. If the temperature much exceeds this, the briquet becomes more coarsely and irregularly crystalline, and at temperatures much less than 2600° C., the crystalline structure, is not sufficiently pronounced.

Within certain limits the lower the sintering or heat treating temperature, the higher is the initial temperature necessary for forging. While cold-working is more important than hot-working to produce the amorphous condition desired, the cold-working stage must be approached by such slow degrees as shall prevent the destruction of the material in the process; for until sufficient amorphous material has been built into the metal by mechanical working at elevated, though constantly decreasing temperatures, the metal will not admit of any cold-working whatever. With pure tungsten subjected to 2600° C., for practical shop work, about 1500° C. is recommended, if a more violent distortion be secured, as by swaging or rolling.

With pure molybdenum, the same conditions are present, though the time and temperature required for heat treatment and the temperature required for forging are both lower than for the treatment of tungsten. The best results have been obtained when a briquet made under a pressure of 200,000 pounds per square inch, was subjected for one minute to a temperature of about 2300° C. This ingot could be forged like tungsten, at about 1000° C.

When the ingot is made of a mixture of molybdenum, the formation of crystal growths proceeds in the same manner.

The mixed metals form true, solid solution alloys and possess the qualities of ductility, malleability, rigidity, elasticity, and tensile strength, in a most remarkable degree. These materials, because of their cheapness, strength, and resistance to corrosion, are peculiarly advantageous in many dental, scientific and philosophic uses.

In many cases one of these alloys will be found far superior to either of these metals alone. Thus, in dental use, as in dental pins, it is frequently desirable to employ a rod or wire of great stiffness and reliability, yet with a minimum of size. In many cases tungsten appears to be satisfactory, especially when coated with gold or other non-oxidizable metal, as described in U. S. Patent No. 1,228,194. An alloy of tin, tungsten and molybdenum is superior.

See U. S. Patent 1,246,552 on page 214.

See U. S. Patent 1,252,038 on page 306.

BRITISH PATENTS

CLASS 1-A

7,880 of 1885, Reitz

This describes a bronze which has great power to resist the attack of acids and alkalies, so that it can be used instead of ebonite, porcelain, and like substances. This bronze consists of the following: Copper, 15 parts; tin, 2.34 parts; lead, 1.82 parts; antimony, 1 part. This alloy is worked exactly like common bronze. It is stated that this new bronze "has already been used in chemical works."

1,473 of 1886, Lake

This relates to a process for coating nickel with silver or platinum, or with alloys of these metals, for chemical apparatus. It is mentioned that alloys of silver and platinum perfectly resist acids and alkalies. Sheets of nickel or its alloys, and platinum or silver or their alloys, are united by placing the cleaned surfaces together and subjecting them to heat and pressure; the sheets to be united are enclosed within an envelope of sheet iron or copper or like material, which is folded about the compound plates to prevent access of air; this envelope is prevented from adhering to the plates by placing a layer of magnesia or lime on the surfaces. Nickel wire may be coated with platinum by folding a sheet of the latter round a core of the former and treating as above.

26,940 of 1907, The British Thomson-Houston Company, Limited

This corresponds to U. S. Patent 901,428 on page 19, and 926,980 on page 163.

This corresponds to U. S. Patent 1,110,303.

A known method of facilitating the mechanical working of tungsten consists in alloying or associating the metal with a more fusible metal and subsequently expelling the more fusible metal by heating.

According to the present invention, objects of tungsten and nickel, which metals are known to alloy with each other, are made by intimately mixing the tungsten with nickel, and sintering the metals together by heating below the melting point of tungsten. There is thus produced a ductile mass which can be further worked by drawing, rolling, hammering and the like.

As compared with directly melting together tungsten and nickel, this process has the advantage that the difficulties of fusion are avoided and that vaporization of the other metal, generally unavoidable when the tungsten is fused, is obviated.

When used in suitable proportion, nickel yields with tungsten extremely ductile masses, which have surprising properties. For example, when the nickel added amounts to 10 to 12 per cent., there may be obtained a metal mass, which is nearly insensitive towards chemical reagents, possesses surprising elasticity and great hardness and can be easily hammered, rolled or drawn.

If objects of pure tungsten are to be made, or objects of tungsten with only quite small proportions of nickel, the latter metal can be wholly or partly expelled by heating in a vacuum. The heating is advantageously effected by passage of an electric current through the object.

The aforesaid properties are exhibited only by those alloys in which the percentage of nickel is not less than about one and the percentage of the tungsten is not less than about sixty. If a smaller percentage of tungsten is present, the removal of the nickel by an electric current in a vacuum is not possible without melting the alloy. If less than 1 per cent. of nickel is present the ductility is still very low, and only with some 5 per cent. and more is

an alloy obtained which fulfills all the requirements. A most suitable alloy consists of a mixture of about 85-95 per cent. of tungsten and 15-5 per cent. of nickel, more especially 90 per cent. of tungsten and 10 per cent. of nickel.

In order to obtain an intimate combination of the nickel with the tungsten, it is advantageous to use one or both of the metals in the form of easily reducible chemical compounds; for example, tungsten powder may be mixed with nickel oxide or tungstic acid may be mixed with nickel oxide, or a plastic mass, which consists of colloidal tungsten compounds, may be used in combination with nickel powder or with an easily reducible nickel compound. As plastic masses of tungsten compounds are particularly suitable, the masses described in British Patents Nos. 11,716 of 1907, 16,489 of 1907 and 11,710 of 1908, which have a very high binding power and can be easily reduced to metallic tungsten by hydrogen may be used. The reduced metal being very finely distributed, unites with the added nickel very intimately and sinters with it to a very ductile mass, which can be easily worked to watch springs, chains, parts of apparatus such as points of pincers, knife blades, crucibles and the like, vessels or other objects.

A colloidal solution of a tungsten compound which can be completely reduced by hydrogen, for example, colloidal tungstic acid, or better still, a colloidal plastic mass of tungsten compounds, such as is described in British Patent No. 16,489 of 1907, forms a most suitable binding medium. When using such a binding medium the tungsten and nickel, finely powdered, or an oxide of tungsten and nickelous oxide are mixed with the reducible plastic mass of tungsten compounds, and a rod is fashioned from the mass thus obtained. This rod may contain oxides in such proportion that the finished material will contain 90 per cent. of tungsten and 10 per cent. of nickel; it may be, for example, about 20 to 30 cm. in length and of about 1.2 mm. in diameter. The rod dries very easily and is then very solid; it is placed in an electric furnace consisting of an electrically heated tube. This tube may, for example, be

made of carbon, reinforced with nickel or other metal of great heating capacity, most suitably of quartz. In this tube the rod is so placed that it does not come into contact with the walls of the tube. A stream of hydrogen is passed through the tube and the temperature gradually increased. The reduction of the rod by the hydrogen now begins, and in order that it may be completed and a rod obtained as uniform and solid as possible, it is advisable to increase the temperature quite gradually, so that after about an hour the temperature is about 1100°C . When this condition has been attained the temperature is cautiously raised until it is about 1510°C .

If the metallic mass has not sufficient ductility after the sintering, it may be reheated to about the same temperature for some minutes. The softness and ductility of the mass are thus considered increased.

The most favorable working conditions for making the ductile alloy must be determined, however, by experiment for each case. For instance, a uniform mixture of 10 per cent. of nickel with 90 per cent. of tungsten in a very finely divided state and in the form of a thin rod about 0.6 mm. thick, when heated in a current of hydrogen not very rapid, requires a temperature of about 1650°C ., and should be heated for about 50 seconds. Thicker rods generally require a longer heating, as stated above.

19,564 of 1908, Siemens & Halske Aktien-Gesellschaft

As a material for making projectiles there have been proposed alloys of tungsten and copper or nickel. These alloys, however, contain only a comparatively small proportion of tungsten, for example, 20 per cent.; in our experience they are brittle and are attacked by acids, so that they are inapplicable for the construction of parts of apparatus and tools that are liable to mechanical or chemical attack.

According to the present invention, those parts of apparatus and tools which are exposed to mechanical or chemical attack are made of an alloy of nickel and tung-

sten which can easily be worked, namely, an alloy consisting of more than 60 per cent. of tungsten and more than 1 per cent. of nickel. The excellent properties of alloys of nickel and tungsten, particularly their high mechanical and chemical resistance, are more marked when the proportion of nickel is small, such as in the alloy containing about 10 per cent. of nickel and obtained according to the process described in British Patent No. 17,438 of 1908. Such an alloy is very hard and at the same time very elastic and strong. It is also non-magnetic and has the advantage over tantalum, which has been suggested for the same purposes, that it does not become brittle when heated; moreover, it is much cheaper than tantalum. At low temperatures its resistance to both mechanical and chemical attack is very great; even aqua regia scarcely attacks it. It can be used in the manufacture of watch springs, pens, the points of pincers and for other parts of apparatus and tools which are liable to mechanical or chemical attack.

See British Patent 22,237 of 1908, page 311.

26,380 of 1908, Landenberger

This corresponds to U. S. Patent 964,122 on page 20.

This invention relates to an improved process for the manufacture of metallic alloys, consisting of copper and zinc with such metals as iron, chromium, manganese, tungsten, nickel, cobalt and vanadium, which enables a material of high technical value to be produced at a relatively low cost.

In alloys of this kind it is a troublesome matter to fuse most of the metals mentioned above, and to amalgamate these with copper and zinc are found to be exceedingly difficult operations, owing to the fact that they do not readily become alloyed; such alloys as these are, however, of great importance for technical purposes. To avoid such difficulties it has heretofore been proposed to introduce one

of the constituent metals of the alloys, in the form of a chloride compound, but in accordance with my improved process, the desired alloys may be formed by taking a chloride compound, as the raw or first material, and combining this with copper and zinc in such a manner that the chloride compound is reduced by the alloying metal zinc itself, the alloy thus formed being added to copper in the molten state.

In accordance with the process under the present invention a chromium-zinc-nickel alloy may be made as follows: A quantity of the chloride corresponding to the desired percentage of chromium in the final alloy is taken and this chloride is reduced by zinc, the chromium liberated becoming alloyed in the nascent state with the zinc present in excess. The chromium-zinc alloy thus obtained is then melted and mixed with an appropriate quantity of copper.

The process may be carried into practice in different ways; for example, the zinc may be melted in a closed iron vessel with the necessary quantity of the desired chloride, an addition of about 2 per cent. of aluminium being found to greatly accelerate the reduction of the chloride, although I am aware that it has been proposed to use aluminium in the manner of reducing agent in the manufacture of alloys. The zinc alloy thus obtained is then cast into bars and added to the molten copper.

In this operation chloride of zinc is produced from the chlorides and the zinc, thereby affording the following additional advantage: As is known, in casting all alloys containing a certain quantity of zinc, oxide of zinc is produced and forms accumulations frequently causing loose, spongy places in the walls of the castings.

This undesirable phenomenon does not arise in castings produced in accordance with the present process for the reason that the oxide of zinc produced is dissolved by the chloride of zinc and so does not impair the casting.

As the chlorides of chromium, manganese and tungsten are exceedingly inexpensive as compared with the pure

metals, the present process renders it possible to produce the desired alloys at an extremely low price, such as has not hitherto been possible. The alloys with chromium and manganese are especially important. For instance, they present great strength at ordinary temperatures and also possess the important property that when heated to a high temperature they do not lose their strength. The chromium alloys also exhibit great resistance to chemical agents, because in the manner already referred to, the chromium is reduced to the chloride and is alloyed *in statu nascendi* with the zinc; moreover, the alloys are hardly attacked by such agents as sulphuric acid, nitric acid and hydrochloric acid. In the process described, chlorides may be added in such quantities that the final alloy may contain up to 5 per cent. of the metal thus introduced without necessitating heating to more than the melting point of copper.

An alloy produced in accordance with the present process and consisting of 1 per cent. of chromium or manganese, 58 parts of copper and 40 parts of zinc, presents a strength of 58 kilos, with a limit of elasticity of 29 kilos and extensibility of from 18 to 20 per cent. The metal is very readily worked, presents a fine grain, and compact castings may be made from it in the most difficult forms.

Copper-zinc alloys with the addition of chromium or manganese manufactured in the known manner do not present the resistance to chemical agents referred to above.

The following is an example of a method of carrying the process into practice, with exact quantitative proportions.

In order to produce 100 kilos of bronze melt, 3.2 kgs. of chromium chloride with 40 kgs. of zinc, and after half an hour add 2 kgs. of aluminium; cast the mass into blocks and add to 57 kgs. of molten copper. Instead of the chromium chloride, 2.5 kgs. of either of the manganese chlorides, viz., MnCl_2 or Mn_2Cl_6 (the former being found preferable), may be employed, the operation being otherwise exactly the same. With 4 per cent. of manganese

or chromium in the bronze, 10 kgs. of MnCl_2 or 12.8 kgs. of the Cr_2Cl_6 are used.

28,608 of 1909, Rübel

Alloys of low specific gravity contain magnesium, together with one or more of the metals, iron, manganese, nickel and chromium. These alloys may also contain aluminium, or zinc. Other alloys contain mostly magnesium which constitutes 90 to 97 per cent. of the alloy. In other alloys the magnesium may be replaced by calcium or beryllium. A specified alloy contains 90 per cent. of magnesium, 9 per cent. of copper and 1 per cent. of aluminium. Or 90 to 97 per cent. of magnesium may be combined with one or more of the metals of the iron group or with a combination of these metals and zinc.

The chromium-magnesium alloy is distinguished by its exceedingly high resistance to chemical influences.

29,723 of 1910, Johnson

Platinum osmium alloys contain from 1 to 20 per cent. of osmium and are used for making vessels for scientific purposes. These alloys are more elastic than iridium-platinum alloys.

27,151 of 1911, Sefton-Jones

This invention relates to the production of metallic articles, resistant to inorganic acids both in the diluted as well as in the concentrated state, and especially to receptacles adapted to contain dilute nitric or hydrochloric or other corrosive acids. It is well known that whereas certain mineral acids, such as sulphuric acid, for instance, can be obtained when concentrated in ordinary cast-iron receptacles, without appreciably attacking the receptacles, more dilute acids and especially nitric and hydrochloric acids cannot be contained in such vessels. It is further known that the addition of chromium or silicon to iron in-

creases its power of withstanding heat and chemical action, and also its hardness and brittleness.

By this invention an alloy of iron and chromium with or without a percentage of silicon is obtained, having the property of resisting completely one or more acids such as nitric acid, nitric fumes, other oxides of nitrogen, sulphuric acid, etc., at high or low temperatures, while at the same time remaining sufficiently ductile to be capable of being cast and worked in the ordinary manner as easily as steel. These conditions are fulfilled from chrome-iron alloys containing over 40 per cent. of chromium up to a maximum of 70 per cent. of the same.

Should it be desired to add silicon to the chrome-iron alloy (which depends upon the use to which the iron is to be put) then by adding over 40 per cent., but not more than 70 per cent. of chromium, and not more than 18 per cent. of silicon to commercial pig-iron, a completely acid-proof alloy is obtained. These alloys are quite homogeneous and can be worked in large quantities.

§, 498 of 1912, Kunz-Krause

This invention relates to a process for the production of a ceramic mass as a metal substitute for laboratory implements and apparatus, such as saucers, crucibles, pestles, tubes, dishes, melting plates, etc., and also for implements for treating substances directly, such as spoons, spatulas, scrapers, and the like.

Large quantities of metals of different kinds are used for the manufacture of laboratory implements and apparatus. For these purposes the precious metals, such as gold, silver, platinum and the like, are required; for instance, in the case of platinum spatulas for carrying out melting tests.

According to this invention there is provided a ceramic mass applicable to certain definite purposes and practical uses as above stated, and which has a high conductivity for heat and electricity, and also has a high melting point.

An example for carrying out this process is as follows:

The object in this case being to produce a small spatula, such as is used in laboratories in producing melting tests.

The usual form of spatula for which a substitute is provided is, say, 2 times 3 cms. in dimension, and very thin. Such a spatula is made from porcelain of a refractory type in the well-known manner.

To this porcelain spatula must be imparted the following properties: Good conduction of heat, ready heating and uniform glowing; and secondly, capability of conducting electric currents. The porcelain spatula possesses none of these properties *per se*, and they are attained by impregnating it with metallic material.

It is not to be understood that simple mixing is referred to. The simple admixture of metallic powder would probably produce products wanting in uniformity and exhibiting the desired properties only in places; moreover such a product would be very costly. The object is to provide a porcelain which is completely impregnated with the metallic material and in which the foundation material, and the metal form one homogeneous mass, so that a zone of metal results which is coherently diffused over and throughout the entire spatula, and behaves in a similar manner towards heat and electricity as if the foundation material were not present at all.

Two methods can be used. In connection with both, the spatula should consist of an unglazed or biscuit porcelain and be very porous.

A metallic solution is preliminarily prepared. This solution, the impregnating agent, can be prepared in different ways. One way consists in dissolving any suitable salt of the desired metal. Another way consists in dissolving the oxides, hydroxides, or any other suitable compounds of the metals in question, or using the metallic compounds in suspension in a suitable liquid.

According to the first method, the porcelain mass is mixed with this liquid, well kneaded so that it becomes uniformly saturated with the same, moulded in the form of the spatula, dried and burnt. While being burnt or

fired the non-metallic constituents of the metallic compounds are volatilized and the metal remains distributed very finely and uniformly throughout the whole of the foundation substance.

By the second method the preliminarily baked spatula is immersed in the liquid until it is saturated therewith and is then burnt or fired, the same result being obtained.

The precious metals, such as platinum, gold, silver, etc., are produced in a finished condition by this process. The baser metals at first remain in the form of their oxides and are subsequently reduced by chemical reaction which takes place substantially during burning, by means of a reducing flame so as to form a layer sufficiently deep for the desired purpose. The quantity of metal may, of course, be regulated according to the strength of the solution employed, depending on what is considered suitable for the purpose in view. For example, a solution containing 5 per cent. of metal may be employed. Even if stronger solutions are employed, the cost still remains small.

2,887 of 1913 Haynes

This corresponds to U. S. Patent 1,057,828 on page 24.

11,505 of 1913, Krupp Akt.

This invention relates to vessels, tubes or the like for containing boiling lyes.

The malleable iron hitherto mostly used for the manufacture of such vessels, etc., is strongly attacked by the lyes. Experiments have shown that when exposed to the action of boiling soda lye, malleable iron lost about 25 grams in weight per hour (calculated per square meter of superficial area). In order to obtain vessels which are strong and at the same time capable of resisting the action of lyes, it has been proposed to use nickel steel and a considerable reduction of the loss in weight has, it is true, been thereby effected.

Experience shows, however, that nickel steel of ordinary composition does not satisfy high requirements in its power of resistance to attack by boiling lyes. Now, according to this invention, it is possible, by using a nickel steel containing 25 per cent. and more of nickel, to obtain so high a power of resistance to attack by lyes, that the loss in weight can be practically neglected. By rendering the nickel steel passive, that is to say, by coating the external surface thereof with a thin layer of oxide, it is possible to prevent the steel from becoming attacked by the boiling lye at all.

In order to increase the mechanical strength of the steel, $\frac{1}{2}$ to 2 per cent. of chromium may be added to the nickel steel, without prejudicially affecting the power of resistance of the metal to attack by the lyes.

See British Patent 13,413 of 1913, page 228.

13,415 of 1913, Paset

This invention relates to metal articles such as vessels, tubes, parts of machinery, etc., which articles require great power of resistance to attack by acids and also great strength. The invention consists in employing for the manufacture of these articles, steel alloys which contain from 15 per cent. to 40 per cent. of chromium; 20 per cent. to 4 per cent. of nickel, and up to 1 per cent. of carbon, within which limits the chromium and nickel contents may be chosen as may be desired.

It has long been determined by experiments, that steel alloys of the above described composition possess a very great power of resistance to attack by acids, particularly nitric acid, and at the same time possess great strength.

By heating the alloys to from 1100° to 1200° C., and subsequently rapidly or slowly cooling them down, these alloys attain very great toughness and are also rendered capable of being satisfactorily worked so that they can be worked up into sheets and tubes without difficulty

Iron, nickel, cobalt and their alloys with one another, are obtained in the passive state by alloying them in quantities ranging between 65 and 72 per cent., with between 34.5 and 25 per cent. of chromium and between 5 and 0.3 per cent. of one or more of the metals molybdenum, tungsten, platinum, iridium, osmium, palladium, rhodium and ruthenium, together with one or more of the metals gold, silver, and copper in a total amount ranging between 2 and 0.2 per cent. Impurities such as carbon, silicon, etc., may be removed during the melting of the metals, by adding oxides of these metals, the final traces of oxygen being removed by an addition of magnesium or magnesium alloys.

14,448 of 1914, *Chemische Fabrik Greisheim-Elektron*

It has been heretofore considered that all metals, with the exception of gold, platinum and a few metals of the platinum group, are oxidized by ozone.

An alloy of chromium and iron and especially alloys which contain more than 25 per cent. of chromium, have the power of resisting the action of ozone to a remarkable degree.

Owing to the strong action of the ozone on iron, it could not have been predicted that 25 per cent. of chromium would protect iron from the oxidizing effects of the ozone.

We have further found that the resistance of alloys of chromium with iron to the action of ozone will be greatly increased, if the constituents, chromium and iron, be as pure as possible and especially if they be free, or as nearly free as possible, from carbon. At least 25 per cent. of chromium will be required to impart to the alloy the required resistance to the action of the ozone. The upper limit may vary, but generally speaking, an addition of 40 per cent. of chromium should not be exceeded.

The alloys can be obtained by fusion either by the aluminothermic process, or by the fusion together of their constituents. In the manufacture of alloys of chromium with

iron poor in carbon and capable of resisting the action of ozone, it is best to start from iron and from chromium which are both poor in carbon. The melting process is to be so conducted that the absorption of carbon is avoided, or as far as possible avoided, and it will therefore be advisable to carry out the melting operation on an acid, or basic bed, or in crucibles with an acid, or basic lining. In order to insure an intimate mixture, powerful and protracted heating is necessary. A covering of slag prevents too large a waste of material. The melting point of these alloys is from about 1450° to 1470° C. The alloys of iron and chromium which are free from carbon, or are but poor in carbon, are characterized by their special power for resisting the action of ozone even in the presence of water. They have a homogeneous texture, and a uniform grain, like ingot iron, and like it, they are ductile, and readily acted upon by tools. They can readily be cast, rolled, forged and drawn. If the apparatus, or appliances, are required to be capable of being easily tooled in making them it is necessary to resort to alloys of iron and chromium poor in carbon which have the especial advantage of a greater resistance to the action of ozone.

The alloys described can, if desired, be used for linings of the apparatus or appliances, instead of making the apparatus, or appliances, wholly of such alloys.

Having now particularly described and ascertained the nature of our said invention, and in what manner the same is to be performed, we declare that we are aware it has been proposed to use, for the manufacture of acid and heat-resisting articles, a ductile chromium-iron alloy formed by the addition to pig-iron of over 40 per cent., but not more than 70 per cent. of chromium, and also to combine with such an alloy up to 18 per cent. of silicon, and we make no claim to the manufacture or use of such articles for the said purpose.

See British Patent 8,327 of 1915, on page 312.

U. S. PATENTS

CLASS 1-B

38,301, Farmer, April 28, 1862

Copper and aluminium are alloyed with one or more light colored metals such as silver, zinc, tin, nickel, platinum, or iron. The alloys contain between 80 and 98 per cent. of copper, and the remainder consists of light colored metals; of the light colored metals from 10 to 95 per cent. should be aluminium. Preferably the constituents are combined in molecular proportions which are stated together with the corresponding percentage composition. Neglecting fractions, these proportions are as follows, for various types of alloys:

1. Alloys of 91 to 94 per cent. of copper, 6 to 4 of aluminium, and 2 to 1 of silver, resembling gold and termed "chrysoids," are used for watch cases, chains, and jewelry.

They are hard, tenacious, and ductile.

2. Alloys of 86 to 93 per cent. of copper, 6 to 3 of aluminium and 7 to 4 of zinc are used for wire and have high tensile strength.

3. Alloys for gun metal and wire consist of 92 to 94 per cent. of copper, 2 to 4 per cent. of aluminium, and 5 to 1 per cent. of iron; or of 83 to 86 per cent. of copper, 3 to 2 of aluminium, 8 to 5 per cent. of zinc, and 6 to 5 per cent. of iron.

4. About 2 per cent. of nickel or platinum is alloyed with 91 of copper and 6 of aluminium.

The platinum or the silver give a high luster to the alloy, and the introduction of the platinum renders the alloys less affected by acids.

81,576, Ashcroft, Sept. 1, 1868

The object of my invention is to provide such metals or compositions of metals as will not become corroded by the action of water, steam, air, nor by any other action to which valves are exposed.

My invention consists in making these valves from the following non-corrosive alloys or metals, any and all of which answer the purpose more or less perfectly:

First, an alloy of nickel and copper, free from zinc.

Second, aluminium, alone or alloyed.

Third, an alloy of gold or silver.

Fourth, combinations of the above.

I do not confine myself to any exact proportions in casting these alloys, but, to enable others skilled in the art to make use of the first one mentioned, will state that I have found an alloy containing from 25 to 50 per cent. of nickel, with from 50 to 75 per cent. of copper (entirely free from zinc), to be non-corrosive.

309,011, Tobin, Dec. 9, 1884

My invention relates to certain improvements in compositions of metals.

I find from actual practice that owing to certain peculiarities of my metal it is specially adapted for piston-rings and other rubbing-surfaces, such as the wearing-faces of slide-valves, cross-head guides, and linings for pump-cylinders; also, owing to its non-corrosive character, it is eminently suitable for any part of an engine in which the metal comes in contact with sea-air, sea-water, or chemical vapors. Owing to the great strength and comparative low cost, these alloys can be economically employed in making shafting for launch machinery, tubing, plates, and sheathing for vessels, torpedo boats, boiler-plates, rods, rivets, castings for bronzes, angle-bars, lightning-rods, and wires, including telegraphic and telephonic wire, for which it is peculiarly adapted on account of its nature as a conductor of electricity and ability to withstand strains, thereby ob-

viating sagging when the poles are spaced at long distances.

For the production of one of my high-test alloys I take, for example, 58.22 parts of copper, 39.48 parts of zinc, and 2.30 parts of tin, and preferably melt the tin and copper separately, and then mix the two, and finally add all the zinc, care being taken during the melting operation to provide a reducing atmosphere or otherwise avoid contact of the air, as well as volatilization of the constituent elements of the alloy.

The metals, when thoroughly combined by stirring, may be poured into sand or metal moulds.

I find that the carefully purified and deoxidized compositions of copper, zinc, and tin are phenomenally tough. They are also bright in color, and not easily tarnished, and, as above stated, approximate the remarkable qualities of the typical formula.

573,615, Placet, Dec. 22, 1896

We have ascertained by many experiments that metals and alloys are greatly improved by the addition, even in minute quantities, of chrome. Up to this day these experiments could not be made because the chrome, which was heretofore obtained at high temperatures, was not pure chrome, but simply a carburet of chrome more or less impure. It was impossible to drive off the carbon and other impurities which this carburet of chrome contained, and consequently when it was attempted to make alloys with this carburet of chrome they (these alloys) were found to be completely changed or altered by the carbon and the other impurities which this carburet of chrome carried with it. It is no longer so with the chrome which we have obtained by electrolysis. This chrome is absolutely pure and improves all the metals or alloys with which it may be associated, communicating to them qualities which are its own. It renders them harder, more resisting to shocks, to traction, and to friction. It renders them inalterable

under the destructive action of the atmosphere, dampness, acids, and high temperatures. We obtain these new alloys by introducing directly into the metal or alloy while in fusion pure chrome in desired proportions according to the quality of the metal we wish to obtain. Although chrome does not melt except at an excessively high temperature, which is very difficult to obtain in ordinary furnaces, we nevertheless obtain perfect alloys of chrome and other metals and alloys without necessarily reaching the point of fusion of chrome. This singular fact may be explained by stating that in such case as we have in view a veritable solution of chrome is effected in the other metals in fusion.

Sometimes in order to facilitate the formation of the alloy of chrome with other metals we add to the alloy (in formation) one or more metals which act as auxiliaries, such as zinc, manganese, magnesium, aluminium, antimony, bismuth, palladium, amalgam of sodium, etc., or we add oxides or salts, which by their decomposition at a high temperature leave in the alloy a metal or a body which facilitates the fusion or the formation of the alloy, such as oxide of zinc, oxide of manganese, permanganates, fluosilicates, borates, cyanides, fluorides, chlorides, phosphides, silicides, etc., or of metals which we desire to alloy.

To prevent the oxidation of the chrome at the time that we introduce our alloys, we preliminarily cover the pieces of chrome of more or less thickness with metal which protects them, such as copper, nickel, gold, silver, zinc, tin, platinum, etc. The coating of the chromium with a less oxidizable metal may be effected by electrolytic action in the well-known manner of electroplating; but the coating may be applied in any convenient manner. A few thousandths of pure chrome added to copper, nickel, aluminium, gold, or silver, zinc, lead, tin, etc., suffices to increase in marked degree the hardness and tenacity of these metals. We employ often chrome at from 0.5 per cent. to 15 per cent. or 20 per cent. The alloys with the highest proportions of chrome are generally so hard that they can-

not be worked except on the emery-wheel or other similar grinding device.

The following are, as a matter of example, some of the advantageous results which are produced by the chrome upon metals and alloys: Chrome added in the proportions from 0.5 per cent. to 20 per cent. to copper or copper alloys, such as bronzes, brasses, German silver, etc., improves the metal to such a point that their resistance to rupture becomes equal to that of steel. A small quantity of chrome added to monetary alloys renders them more inalterable and more resisting to friction. A little chrome added to the printing-type renders the alloys more resisting to pressure and to the indispensable cleaning. The chrome renders metals or alloys more resisting to high temperatures for the manufacture of twyers, bed-plates of fire-places, etc., and other implements used in connection with furnaces, etc. It also renders them more resisting to acids, to alkalies, and to other chemical products for the manufacture of chemical apparatus and culinary utensils. The chrome in increasing the hardness of metals renders them more sonorous, and to this end can be used in the manufacture of bells, trumpets, piano-wires, etc. It also increases the electrical resistance of manganese, ferromanganese, ferronickel, and other metals which serve the purpose of making wires of high electrical resistance. Chrome added to copper, platinum, palladium, manganese, tungsten, cadmium, etc., increases the anti-magnetic properties of these metals, and are used in the construction of watches, chronometers, and other instruments which should be insensible to magnetic perturbations.

578,465, *Parnacott*, March 9, 1897

The object of this invention is to produce a white metallic alloy of good color, great tensile strength and elasticity, non-corrodible, impervious to the action of hydrochloric acid in sea-water, and all atmospheric influences, suitable for use in sea-water, for machinery, and all domestic purposes and appliances.

The proportions of the metals used are, by weight, say, copper, 44; nickel, 20; spelter, 25; iron, 7; cobalt, 3; magnesium, 1; total, 100.

The order of mixing the metals is as follows: First, I melt the nickel, and after clearing it from impurities to refine and toughen it I add the magnesium in minute charges while well stirring with plumbago rods. I then mix in an equal quantity of copper. Second, in another crucible I melt the other portion of copper with the iron and cobalt, and when they are thoroughly fused I pour the contents into the first-mentioned mass, keeping the same well stirred. When I see the metals are assuming the desired color, I stir with a charred wooden rod and add the spelter and keep stirring until all the dross and impurities are on the top of the crucible. I then skim off same and pour the fluid alloy quickly into ingots or moulds, as required.

These alloys will resist oxidation, polish most brilliantly, and always retain their color—in fact, improve in appearance by wear, and will withstand the destructive influence of hydrochloric acid in sea-water and resist chemical fumes and atmospheric impurities.

633,743, Van Wart, Sept. 26, 1899

An aluminium alloy which has extreme non-corrosiveness is made up as follows:

Aluminium	100 parts
Copper	1 to 10 parts
Zinc	$\frac{1}{8}$ to 6 parts
Silver	$\frac{1}{8}$ to 6 parts
Tin	$\frac{1}{8}$ to 4 parts
Phosphorus	$\frac{1}{16}$ to 1 part

The copper is first melted and then the zinc and silver are added and stirred. The aluminium is then added. The pot is then withdrawn, and the tin is added together with the phosphorus.

The mixture is now well stirred.

666,670, *Hennig, Jan. 29, 1901*

Alloys consisting of 50 to 65 parts of copper, 33 to 50 parts of zinc, 1 to 15 parts of iron and from 1/6 to 8 parts of manganese (or cobalt) have great tensile strength and are not readily acted upon by acids or alkalis.

682,330, *Leyendecker, Sept. 10, 1901*

By adding a small amount of copper to lead, the amount of copper being from 1/10 to 5/10 per cent. of the quantity of lead, it is rendered much less sensitive to the action of acids and other chemicals.

Another suitable alloy is 1,000 parts of lead, 1 to 5 parts of copper and 1 to 3 parts of antimony.

909,283, *Clapp, May 2, 1908*

This invention is a ferrous alloy, or steel, characterized by great hardness, toughness, tensile strength and resistance to corrosion.

The alloy primarily comprises iron, iridium and platinum. Percentage of iron may be from 40 to 90; of iridium from 1 to 30; and of platinum from 0.2 to 10. The iridium acts as a hardening agent and the platinum in the iron prevents segregation upon cooling, and produces a homogeneous fine-grained product. It is found desirable to add to the alloy molybdenum and preferably copper and nickel. The percentage of molybdenum may vary from 1 to 51; of copper from 0.5 to 15; and of nickel from 0.5 to 15. In producing the alloy the iron, for example, in the form of open-hearth steel, may be first melted and the other metals added thereto.

I claim:

1. An alloy comprising iron, iridium, and platinum, the percentage of iron being greater than that of the iridium or platinum.

2. An alloy comprising iron, iridium, platinum, and a metal or metals capable of facilitating solutions of the iridium and platinum in molten iron.

3. An alloy comprising iron, iridium, platinum and molybdenum.

See U. S. Patent 981,542 on page 171.

See U. S. Patent 993,042 on page 174.

1,005,115, Hatlanek, Oct. 3, 1911

It is well known that the residues of the combustion of the explosive substances employed adhere to those parts of firearms which are brought into contact with the powder gases and cause rusting of these parts, where they are made of steel and are not thoroughly cleaned very soon after shooting. This rusting action is so powerful that the spots and pits of rust, which form when the weapon is insufficiently cleaned, impair its shooting accuracy to such an extent as to make the weapon quite useless. This rusting becomes still worse if accompanied by moisture for which reason it makes itself evident with particular unpleasantness in damp weather. Now, experiments which have been carried out show that nickel steel alloyed with copper possesses, in addition to the power of resistance imparted to it against repeated heating and cooling by alloying it with copper, an additional and surprising power of resisting the rusting action of nitric acid, nitric anhydride, carbonic acid and moisture, whereby a steel of this kind is particularly suitable for resisting the rust producing action of the residues of the explosive substances used in firearms. This power of resistance to rusting becomes specially evident when the percentage of nickel is made slightly higher, notwithstanding the fact that it is well known that nickel possesses little power of resistance to nitric acid. It has been found that a steel containing 7 per cent. of nickel in addition to 4 per cent. of copper remains practically free from rust, upon being subjected for

days to the simultaneous action of the vapors of nitric acid, nitric anhydride, carbonic acid and a moist atmosphere.

With regard to the manufacture of a steel of the composition forming the subject matter of this invention, it is advisable to use as pure copper as possible as copper frequently contains substances which are injurious to steel. The copper may be added at any desired time to the steel. If the steel be manufactured in crucibles, the copper is best melted simultaneously with the steel; if on the other hand the steel be manufactured in a Martin or electrical furnace it is advisable not to put the copper into the furnace until the end of the process, as it is easier in the absence of the copper to determine the progress of the metallurgical process by the aid of tests taken from the bath. Earlier addition of the copper is of course not impossible. The nickel for the production of the nickel steel containing copper may of course be added in exactly the same way and at the same time as in the production of a nickel steel, which does not contain any copper. An alloy of copper and nickel may of course also be used for the production of the copper nickel steel.

I claim as my invention:

As a new article of manufacture, a gun barrel or analogous object subject to repeated heating during use made of metal composed principally of ordinary steel alloyed with from 4 to 5 per cent. of copper.

1,040,027, Schmid, Oct. 1, 1912

The invention relates to an alloy of copper and zinc having 56 to 62 per cent. copper, to which, as an exclusive adjunct, silicon and tin are added. A metal is then obtained, which, in a raw cast condition, combines all properties of most value in practice, viz., high limit of elasticity, toughness, small liability to formation of hollow spaces, and, to separation when solidifying in the mould, high resistance to the attack of salt solutions (sea water), diluted acids, and alkalies, and no undue resistance to the action of cutting tools. Such alloys having 56 to 62 per

cent. copper; 43.3 to 35 per cent. zinc; 0.2 to 1.5 per cent. silicon and 0.5 to 1.5 per cent. tin have, in a raw cast condition, limits of elasticity of 12.7 to 19 tons per square inch, a tensile strength of 30.5 to 34.9 tons per square inch, extensions of 25 to 35 per cent., and a high resistance to the notch bending test. When becoming solid there is only a very slight tendency to the formation of hollow spaces and no separation even in the case of large castings. In acids, salt solutions, and alkalies, they are very durable. In spite of their high degree of toughness they can be easily shaped, planed, filed, turned, etc., and, when red hot, they can be wrought, rolled and pressed, and, at a normal temperature, drawn, rolled and hammered. This is a result which is not obtained by any ordinary or special brass.

As an example for the practical production of the alloy of copper, zinc, silicon, and tin forming the subject matter of the invention, the following proportions may be given: 58 pounds copper are melted and well superheated, whereupon, while stirring said molten copper, 1 pound of silicon copper having 30 per cent. silicon, 1 pound tin and 40 pounds zinc are dissolved.

What I claim and desire to secure by Letters Patent of the United States is:

1. An alloy of copper, zinc, tin and silicon containing 56 to 62 per cent. of copper.
2. An alloy of 56 to 62 per cent. copper, 43.3 to 35 per cent. zinc, 0.2 to 1.5 per cent. silicon and 0.5 to 1.5 per cent. tin, substantially as set forth.

See U. S. Patent 1,057,423 on page 178.

*1,077,977, Fuller (Assigned to General Electric Co.),
Nov. 11, 1913*

Nickel-copper alloys in which nickel predominates, possess very useful properties. This is particularly true

of Monel metal, which is a natural alloy containing nickel, copper and a small percentage of other metals, such as iron and manganese, the ratio of nickel and copper being about 2 to 1. This metal is non-oxidizable, even at a high temperature, is not affected by atmospheric conditions, and resists the corrosive action of acids; salt water, etc. It is very strong, hard, ductile, and insusceptible of a very high polish. The relatively high cost of this metal and the fact that it is not easily workable as some more commonly used metals, however, tends to limit its use in the arts.

This invention provides for a composite metal formed by uniting a Monel metal to a less expensive metal as iron or steel.

This is done by an intermediate cupreous layer. The composite metal may be rolled, drawn, etc. A plate of the Monel metal may be united to a plate of iron or steel by inserting a sheet of copper between the plates and raising the temperature to the melting point of copper in a non-oxidizing atmosphere, no compression of the plates and no flux being required.

The Monel metal is preferably united to a plate of steel comprising about 0.13 per cent. carbon and 0.36 per cent. manganese. It is preferred to unite the plates in a hydrogen atmosphere, although the process may be carried on in an electric vacuum furnace utilizing carbon electrode.

The composite metal may be used for making any article subject to oxidizing or corroding influences, for lining ovens, etc. The Monel metal may be united to a high resistance alloy containing 77 per cent. iron, 17 per cent. nickel, 4 per cent. chromium, and 2 per cent. manganese.

I claim:

1. A composite metal body comprising a layer consisting mainly of iron and a layer of an alloy of nickel and copper in which nickel predominates, the said layers being intimately united by a cupreous film or layer.

2. A composite metal comprising a plate of ferrous metal having a sheet of nickel-copper alloy united to each side thereof by a layer of copper.

1,126,629, *Gleason (Assigned to Neu-Metals and Process Company)*, Jan. 26, 1915

It is the object of my invention to provide an alloy that is practically non-corrosive, and which, though hard and tough, may be rolled to sheet form or readily machined without being annealed.

Heretofore it has been assumed, as the result of experience, that copper will not alloy with iron unless the latter be pure. Therefore, as the iron which I employ contains carbon, it is to be understood that the capacity of the copper to alloy therewith is due to the presence of boron.

In carrying out my process I prefer to first incorporate the boron in the copper, preferably by subjecting the copper to the action of boron fluoride while the copper is molten, which results in the deposit of boron in the graphitoidal state in the copper when the latter cools. In forming my improved alloy I employ such boron copper in which boron is in excess, viz., in greater quantity than will combine with the copper and as the boron associates with iron as readily as silicon, regardless of the carbon content of the iron, the copper is thereby caused to alloy with the iron and carbon, forming a homogeneous mixture. For instance, by taking 80 parts Bessemer scrap and fusing it in a Hawley-Schwartz furnace and adding 20 parts of copper containing boron in excess, I produce an alloy which may be cast in ordinary sand moulds, forming castings which are homogeneous and easily machined.

I claim:

1. An alloy containing iron, boron and copper; including approximately 80 per cent. of iron.
2. An alloy containing iron, copper and boron, the principal ingredient of which is iron.

*1,151,160, Brown (Assigned to Edward R. Cooper),
Aug. 24, 1915*

This invention relates to alloys and processes of producing the same; and it comprises as a new article an alloy comprising zirconium and iron, said alloy containing advantageously between 40 and 90 per cent. of zirconium with the residue mainly iron, or an iron group metal, and said alloy also advantageously comprising a certain amount of titanium, and also comprising in certain cases a small amount of aluminium or other metal; and it also comprises a filament or other luminescent body composed of said alloy and it further comprises a method of producing such alloys wherein zirconium and iron compounds are co-reduced in the presence of sufficient titanium compounds to produce certain advantageous effects and to insure the entry of a small amount of metallic titanium into the alloy produced; all as more fully hereinafter set forth and as claimed.

Numerous attempts have been made to obtain alloys of zirconium which could be worked up into forms commercially useful, but such attempts have been heretofore largely unsuccessful. Zirconium itself is a hard, brittle substance existing in several allotropic forms, all of which are easily fractured and possess little or no ductility or malleability. These properties have also characterized practically all the alloys or metal mixtures heretofore produced in which zirconium was present in more than comparatively small proportions. Moreover it has been found extremely difficult to alloy zirconium with other metals by direct addition of the one metal to the other with production of uniform and homogeneous ductile and malleable alloyed products; products which are susceptible of being treated by metal-working processes such as drawing, forging, rolling, casting, and the like. The physical and chemical properties of these directly produced alloys prevent such manipulation.

According to the present invention true alloys of zirconium with iron, or another metal of the iron family, are

produced by the simultaneous reduction of the constituent metals from compounds containing them. Under these conditions the zirconium and the iron group metals readily unite to form homogeneous alloys of varying composition depending upon the relative quantities of the materials employed and the conditions of reduction. The alloys thus produced are of a type hitherto unknown among metallic zirconium combinations. They exhibit practically no tendency to oxidize and are highly resistant to most chemical reagents. In appearance they are truly metallic, and they can be produced in compact bodies which upon grinding and polishing, exhibit bright metallic surfaces of a silvery steel-like luster. Alloys may be produced which are tough and are malleable and ductile in greater or less degree. They are adapted to be worked up into shaped articles having utility in many connections.

A highly important application of these alloys is in the manufacture of drawn filaments, glowers or other luminescent bodies for electric lamps. In use, the filaments have the property of selective radiation (that is emit more light than corresponds to the temperature), and may be used to make lamps which require considerably less than the usual wattage per candlepower. They possess a remarkably high degree of luminescence at relatively low filament temperatures and are thus very efficient sources of light. While other metals of the iron group than iron itself, such as nickel, cobalt, or manganese, or alloys or mixtures thereof, are capable of use in the present invention, they are not in practice as desirable as iron. For the present purposes, iron is by far the most satisfactory metal of the iron group. The relative proportions of iron and zirconium in alloys under the present invention may vary widely. For most purposes it is desirable to have proportions which will give alloys which are malleable and ductile, or have good tensile strength. For binary zirconium-iron alloys, the proportion of zirconium should not fall much below, say, 40 per cent. or thereabout, since with lower percentages of this metal the advantageous

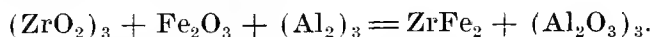
properties of the alloys are not sufficiently in evidence. Higher percentages of zirconium in such binary alloys are still more desirable for various reasons; and the alloys of from approximately 60 to 90 per cent. zirconium content with 40 to 10 per cent. of iron are particularly advantageous.

The excellence of these zirconium alloys may be considerably enhanced and many desirable properties attained by the inclusion of a small amount of titanium in the alloy, either by co-reduction of titanium with the other constituents, or by separate addition of titanium to a preformed alloy. The allowable amount of titanium so present is not rigidly restricted, but very small quantities prove efficacious in practice. As little as 0.10 per cent. serves the present purpose in some instances, and it is seldom necessary in alloys for most purposes that the titanium content shall exceed 2 or 3 per cent. These small amounts of titanium give enhanced strength and toughness to the zirconium alloys, and also increase their electrical properties. The ductility and malleability are also more pronounced. Furthermore, in the manufacture of these alloys by co-reduction of the component metals, the presence of the titanium compounds in the mixture reduced has a useful effect in preventing the undesirable retention of oxygen and oxygen compounds in the alloy or resultant melt. The presence of titanium also operates to exclude nitrogen, carbon and other metalloids from the alloy produced. Oxygen and other metalloids have an undesirable effect on malleability, ductility and texture. Ternary alloys containing a certain amount of titanium with preponderating proportions of zirconium and iron have certain decided advantages over the simple binary alloys for many purposes. Finally, the addition of small amounts of other metals such as aluminium, tantalum, columbium (niobium), etc., give quaternary and still more complex zirconium-iron alloys which for some purposes offer particular advantages and in them the relative proportions of zirconium and iron may often, with advantage, vary more widely than in the

simple binary zirconium iron alloys. It is to be understood, however, that in all these alloys under the present invention the combined zirconium-iron content preponderates over the other metals. Typical analyses of quaternary alloys of the present invention comprising zirconium, iron, titanium and aluminium are as follows: zirconium 65.78 per cent., 8.43 per cent., 32.97 per cent.; iron, 26.39 per cent., 90.97 per cent., 49.21 per cent.; titanium, 0.12 per cent., 0.13 per cent., 0.42 per cent.; aluminium, 7.71 per cent., 0.47 per cent., 17.40 per cent.

The described alloys are substantially iron-zirconium alloys, other metals forming a minor fraction. And, for practical purposes, these alloys may be looked upon as zirconium alloyed with iron or its equivalent, an iron-rich ferrous alloy.

The process of making the described alloys under the present invention is one of co-reduction of compounds containing zirconium and iron in such a manner that the two metals are presented to each other in a nascent reactive condition. It is best that this reduction occur in the presence of a titaniferous compound, since as before stated, the inclusion of a small percentage of titanium in the alloy produced is especially valuable and the presence of titanium during the reduction is desirable for the other reasons stated. A convenient method, especially where it is desired to have aluminium present in the alloy, as is often the case, is to reduce mixed oxides of iron and zirconium by means of finely divided aluminium, the reaction being started with any firing means or materials such as magnesium, barium oxides, etc. In making an alloy of iron and zirconium containing about 44.7 per cent. zirconium the following equation may serve to represent the reaction of reduction by aluminium:



The process of reduction may also be carried out by suitably heating the mixed oxides in a graphite crucible as by means of the oxyacetylene flame, or electrically. Or, a

mixture of titaniferous oxide of iron, and the mineral zircon, or other zirconium-containing materials, such as zirconia together with suitable amounts of titaniferous minerals such as rutile, ilmenite, sphene, titanite oxide, etc., may be heated as before described. Fluxes and slag forming bodies such as silica, soda, etc., may be employed. The mineral ilmenite is a source of titanium convenient to employ in the present process.

The alloys thus produced may be mechanically worked in any suitable way. In making filaments, the alloys, in the form of rods, produced by casting or by otherwise suitably shaping the alloys produced as above described may be heated to the necessary temperature, rolled, drawn, swaged or extruded through dies to size, the alloy rod being conveniently heated by passage of a current there-through during drawing. With many of the present alloys no special precautions need be taken to avoid oxidation during working, but where necessary or desirable, working may be carried on *in vacuo* or in an inert atmosphere.

In addition to their utility for incandescent lamp filaments and for glowers, alloys under the present invention may be usefully employed in forming arcs. As stated, the present materials give out more light than is equivalent to their temperature. Being resistant to acids and corrosion, the alloys may be used for various shaped articles for ornamental and other purposes, such as spark points, etc. Another field of utility for these alloys is in the manufacture of transformer elements.

Halogen compounds, such as fluorides, chlorides, etc., of the various metals may be used in making the alloys by co-reduction; but their use offers no advantage over that of the employment of the oxidized compounds of the metals as described.

What I claim is:

1. As a new article, an alloy comprising not less than about 40 per cent. and not more than about 90 per cent. zirconium together with an iron group metal.

2. As a new article, an alloy comprising not less than about 40 per cent. and not more than about 90 per cent. zirconium together with iron.

3. As a new article, an alloy comprising approximately between 60 and 90 per cent. zirconium together with an iron group metal.

4. As a new article, an alloy comprising approximately between 60 and 90 per cent. zirconium together with iron.

See U. S. Patent 1,168,074 on page 194 .

See U. S. Patent 1,175,724 on page 197 .

1,180,996, Gaskill (Assigned one-half to Charles F. Johnson), April 25, 1916

This invention relates to a new and a useful composition of matter, more particularly a white metal alloy which I call manganese silver, the object of the invention being to produce a novel and metallic compound or alloy which may be used advantageously as a substitute for nickel and which is extremely hard, preserves its color, resists oxidation and the tarnishing and corrosive effects of many gases and liquids and which is capable of being readily machined, is also adapted to be rolled in sheets, is ductile, malleable, and which also may for certain specific purposes be advantageously used as a substitute for steel.

The said invention consists of the composition of ingredients hereinafter fully described and particularly pointed out in the claim.

My improved composition consists of copper, nickel, zinc, manganese copper and in some instances also aluminium and phosphor tin.

For making a composition which will machine, I take of copper, 56 parts; nickel, 15 parts; zinc, 25 parts; aluminium, 1/10 per cent.; lead, 1 3/4 per cent.; manganese (pure, carbon free and free from iron), 4 ounces, and magnesium, 1 ounce.

To produce a composition from which castings can be made I use of copper 50 parts; nickel, 10 parts; zinc, 35 parts; lead, 2 parts; aluminium alloy, 2 parts, and manganese, 1 part.

To produce a composition especially adapted for use in the manufacture of surgical and dental instruments and the like I use copper, 33 parts; nickel, 33 parts; zinc, 32 parts; manganese, 2 parts.

To produce a composition which is ductile and which may be readily rolled in sheets and used for making cooking utensils, tableware, automobile rims, cans for ice cream freezers, shipping cans and the like, which will not corrode, rust or oxidize and which is free from poison in its composition I also provide of copper, 60 parts; nickel, 12 parts; zinc, 18 parts; manganese, 5 parts; aluminium, 2 parts; magnesium, 1 part and phosphor tin, 2 parts.

In the preparation of my composition I prefer to first melt the copper in a suitable crucible and as soon as the copper assumes the molten condition I add the quota of nickel, zinc, and the other ingredients and allow the same to become fused and cause the ingredients to be thoroughly mixed by occasional stirring. The composition is then complete and can be cast into whatever form may be desired.

I claim:

The herein described composition of matter containing copper, nickel, zinc, manganese, aluminium, magnesium and phosphor tin.

See U. S. Patent 1,211,943 on page 199.

See U. S. Patent 1,229,037 on page 212.

*1,244,742, Jones (Assigned one-half to Fred J. Molt),
Oct. 30, 1917*

The object of my invention is the production of a composition metal which has the appearance of silver and the strength of steel, but which will not rust by exposure to

the atmosphere or to anything else which ordinarily causes metals to corrode; a further object being to produce a metal which will resist most acids and which will take a high polish, can be cast or rolled into bars or sheets, or forged or otherwise fashioned into desired forms, and which is very tough and from which springs and like articles may also be formed.

My composition consists of the following ingredients combined in the manner set out.

Nickel	67.8 per cent.
Copper	28.0 per cent.
Manganese	02.5 per cent.
Iron	01.5 per cent.
Vanadium	00.2 per cent
<hr/>	
	100.0 per cent.

In the practice of my invention the nickel, copper, manganese and iron are preferably first melted in any suitable furnace or crucible, and the vanadium is mingled therewith after the other metals have been melted and drawn into the ladle or in cases where crucibles are employed or used for melting, just before the metal is to be poured, or in other words, as soon as the melting product is taken from the furnace, and the product thus formed is thoroughly stirred and the various component parts mingled.

It is possible, however, to mingle all the component parts, including the vanadium, and then melt the product, but the process of procedure first above named is the one preferred.

The vanadium adds considerably to the strength and toughness of the finished metal and the amount of vanadium can be varied slightly, but should preferably never be over 1 per cent. of the total mixture, and when the amount of vanadium employed varies from the figures given in the formula, the amount of copper should also be varied to an equal extent.

I may also add carbon to the above ingredients, to the extent of from .18 to .20 per cent., and this will make the metal product harder, the temper depending on the percentage of carbon employed.

My invention is not limited to the exact proportions of the various ingredients thereof, as herein set out, and changes therein and modifications thereof may be made, within considerable limits, without departing from the spirit of the invention or sacrificing its advantages.

I claim:

1. The composition metal herein described containing nickel, copper, manganese, iron and vanadium.
2. A metallic compound comprising nickel, copper, manganese, iron, vanadium and carbon, combined.

See U. S. Patent No. 1,248,621 on page 215.

1,248,648, Grenagle, Dec. 4, 1917

This invention relates to alloys and processes of producing the same; and it comprises as a new article an alloy comprising zirconium and iron, said alloy containing advantageously between 40 and 90 per cent. of zirconium with the residue mainly iron, or an iron group metal, and said alloy also advantageously comprising a certain amount of titanium and also comprising in certain cases a small amount of aluminium or other metal; and it also comprises a filament or other luminescent body composed of said alloy and it further comprises a method of producing such alloys wherein zirconium and iron compounds are co-reduced in the presence of sufficient titanium compounds to produce certain advantageous effects and to insure the entry of a small amount of metallic titanium into the alloy produced; all as more fully hereinafter set forth and as claimed.

Numerous attempts have been made to obtain alloys of zirconium which could be worked up into forms commercially useful, but such attempts have been heretofore large-

ly unsuccessful. Zirconium itself is a hard, brittle substance existing in several allotropic forms, all of which are easily fractured and possess little or no ductility or malleability. These properties have also characterized practically all the alloys or metal mixtures heretofore produced in which zirconium was present in more than comparatively small proportions. Moreover it has been found extremely difficult to alloy zirconium with other metals by direct addition of the one metal to the other with production of uniform and homogeneous ductile and malleable alloyed products; products which are susceptible of being treated by metal-working processes such as drawing, forging, rolling, casting and the like. The physical and chemical properties of these directly produced alloys prevent such manipulation.

According to the present invention true alloys of zirconium with iron, or another metal of the iron family, are produced by the simultaneous reduction of the constituent metals from compounds containing them. Under these conditions the zirconium and the iron group metals readily unite to form homogeneous alloys of varying composition depending upon the relative quantities of the materials employed and the conditions of reduction. The alloys thus produced are of a type hitherto unknown among metallic zirconium combinations. They exhibit practically no tendency to oxidize and are highly resistant to most chemical reagents. In appearance they are truly metallic, and they can be produced in compact bodies which upon grinding and polishing, exhibit bright metallic surfaces of a silvery steel-like luster. Alloys may be produced which are tough and are malleable and ductile in greater or less degree. They are adapted to be worked up into shaped articles having utility in many connections.

A highly important application of these alloys is in the manufacture of drawn filaments, glowers or other luminescent bodies for electric lamps. In use, the filaments have the property of selective radiation (that is emit more light than corresponds to the temperature), and may be

used to make lamps which require considerably less than the usual wattage per candlepower. They possess a remarkably high degree of luminescence at relatively low filament temperatures and are thus very efficient sources of light. While other metals of the iron group than iron itself, such as nickel, cobalt, or manganese, or alloys or mixtures thereof, are capable of use in the present invention, they are not in practice as desirable as iron. For the present purposes, iron is by far the most satisfactory metal of the iron group. The relative proportions of iron and zirconium in alloys under the present invention may vary widely. For most purposes it is desirable to have proportions which will give alloys which are malleable and ductile, or have good tensile strength. For binary zirconium-iron alloys, the proportion of zirconium should not fall much below, say, 40 per cent. or thereabout, since with lower percentages of this metal the advantageous properties of the alloys are not sufficiently in evidence. Higher percentages of zirconium in such binary alloys are still more desirable for various reasons; and the alloys of from approximately 60 to 90 per cent. zirconium content, with 40 to 10 per cent. of iron are particularly advantageous.

The excellence of these zirconium alloys may be considerably enhanced and many desirable properties attained by the inclusion of a small amount of titanium in the alloy, either by co-reduction of titanium with the other constituents, or by separate addition of titanium to a preformed alloy. The allowable amount of titanium so present is not rigidly restricted, but very small quantities prove efficacious in practice. As little as 0.10 per cent. serves the present purpose in some instances, and it is seldom necessary in alloys for most purposes that the titanium content shall exceed 2 or 3 per cent. These small amounts of titanium give enhanced strength and toughness to the zirconium alloys, and also increase their electrical properties. The ductility and malleability are also more pronounced. Furthermore, in the manufacture of these alloys by co-reduction of the component metals, the presence of the

titanium compounds in the mixture reduced has a useful effect in preventing the undesirable retention of oxygen and oxygen compounds in the alloy or resultant melt. The presence of titanium also operates to exclude nitrogen, carbon and other metalloids from the alloy produced. Oxygen and other metalloids have an undesirable effect on malleability, ductility and texture. Ternary alloys containing a certain amount of titanium with preponderating proportions of zirconium and iron have certain decided advantages over the simple binary alloys for many purposes. Finally, the addition of small amounts of other metals, such as aluminium, tantalum, columbium (niobium), etc., give quaternary and still more complex zirconium-iron alloys which for some purposes offer particular advantages, and in them the relative proportions of zirconium and iron may often, with advantage, vary more widely than in the simple binary zirconium iron alloys. It is to be understood, however, that in all these alloys under the present invention the combined zirconium iron content preponderates over the other metals. Typical analyses of quaternary alloys of the present invention comprising zirconium, iron, titanium, and aluminium are as follows: zirconium, 65.78 per cent., 8.43 per cent., 32.97 per cent.; iron, 26.39 per cent., 90.97 per cent., 49.21 per cent.; titanium, 0.12 per cent., 0.13 per cent., 0.42 per cent.; aluminium, 7.71 per cent., 0.47 per cent., 17.40 per cent.

The described alloys are substantially iron-zirconium alloys, other metals forming a minor fraction. And, for practical purposes, these alloys may be looked upon as zirconium alloyed with iron or its equivalent, an iron-rich ferrous alloy.

The process of making the described alloys under the present invention is one of co-reduction of compounds containing zirconium and iron in such a manner that the two metals are presented to each other in a nascent reactive condition. It is best that this reduction occur in the presence of a titaniferous compound, since as before stated, the inclusion of a small percentage of titanium in

the alloy produced is especially valuable and the presence of titanium during the reduction is desirable for the other reasons stated. A convenient method, especially where it is desired to have aluminium present in the alloy, as is often the case, is to reduce mixed oxides of iron and zirconium by means of finely divided aluminium, the reaction being started with any firing means or materials such as magnesium, barium oxides, etc. In making an alloy of iron and zirconium containing about 44.7 per cent. zirconium the following equation may serve to represent the reaction of reduction by aluminium:



The process of reduction may also be carried out by suitably heating the mixed oxides in a graphite crucible as by means of the oxyacetylene flame, or electrically. Or, a mixture of titaniferous oxide of iron, and the mineral zircon, or other zirconium-containing materials, such as zirconia together with suitable amounts of titaniferous minerals such as rutile, ilmenite, sphene, titantic oxide, etc., may be heated as before described. Fluxes and slag forming bodies such as silica, soda, etc., may be employed. The mineral ilmenite is a source of titanium convenient to employ in the present process.

The alloys thus produced may be mechanically worked in any suitable way. In making filaments, the alloys, in the form of rods, produced by casting or by otherwise suitably shaping the alloys produced as above described may be heated to the necessary temperature, rolled, drawn, swaged or extruded through dies to size, the alloy rod being conveniently heated by passage of a current there-through during drawing. With many of the present alloys no special precautions need be taken to avoid oxidation during working, but where necessary or desirable, working may be carried on *in vacuo* or in an inert atmosphere.

In addition to their utility for incandescent lamp filaments and for glowers, alloys under the present invention

may be usefully employed in forming arcs. As stated, the present materials give out more light than is equivalent to their temperature. Being resistant to acids and corrosion; the alloys may be used for various shaped articles for ornamental and other purposes, such as spark points, etc. Another field of utility for these alloys is in the manufacture of transformer elements.

Halogen compounds, such as fluorides, chlorides, etc., of the various metals may be used in making the alloys by co-reduction; but their use offers no advantage over the oxidized compounds of the metals as described.

What I claim is:

1. As a new article, an alloy comprising not less than about 40 per cent. and not more than about 90 per cent. zirconium together with an iron group metal.
2. As a new article, an alloy comprising not less than about 40 per cent. and not more than about 90 per cent. zirconium together with iron.

See U. S. Patent 1,257,272 on page 216.

See U. S. Patent 1,274,250 on page 219.

BRITISH PATENTS

CLASS 1-B

42 of 1863

This corresponds to U. S. Patent 38,301 on page 72.

3,941 of 1868, Bousfield

This corresponds to U. S. Patent 81,576 on page 73.

1,923 of 1872, Woods & Clark

The improvements consists in combining either iron or steel with various alloys of the hard and difficult oxidizable metals, such as certain alloys of chromium and tungsten, by the action of which alloys on the iron or steel either or both are rendered less subject to rust or oxidation, and the toughness of the iron or the temper of the steel are very materially improved.

In carrying out our said invention in practice we mix in a crucible or in a blast furnace or in any other suitable furnace, a certain quantity of iron or of steel of any degree of hardness or description, and of any make (preferably Bessemer steel) with an alloy of chromium and tungsten either in the metallic state or in the form of mixed oxides, and fusing the whole in the presence of carbonaceous matter, by which the iron or steel becomes alloyed with the chromium and tungsten. The alloy of chromium and tungsten which we prefer to use for general purposes consists of 10 per cent. tungsten and 90 per cent. of chromium, or an equivalent proportion of their oxides; of this alloy we use from 1 to 5 per cent. in combination

with the iron or steel according to the nature of the metal to be produced. The alloy we prefer to use for anti-acid metal consists of 5 per cent. of tungsten and 95 per cent. of chromium combined in the proportion of 33 per cent. of alloy to 67 per cent. of steel. This metal is also very hard, is of a silver color, takes a high polish, which it retains in a damp or oxidizing atmosphere, and is accordingly extremely useful for various purposes, amongst which we particularize the following: speculum metal and similar purposes where high reflective qualities are required, various parts of instruments where German silver is now used, for coinage metal, and for cutlery which has to be used in contact with acids.

1,143 of 1877, Webster

(Part of this patent corresponds to U. S. Patent 274,538.)

Alloys may be produced with or without the admixture of other metals or alloys, to resist oxidation and the fumes of acids. To make a hard bismuth bronze or alloy, 1 part by weight of bismuth, 3 of lead, 6 of zinc, 15 of nickel, 25 of copper, and 50 of antimony are melted and thoroughly amalgamated in a pot or crucible. The resulting hard alloys may be made into reflectors and other articles requiring a high polish or hardness, and also into bearings, valves, etc. A softer bronze is made from 1 part of bismuth, 5 of lead, 12 of zinc, 30 of nickel and 52 of copper. These alloys resist oxidation and keep their color better than similar alloys hitherto made. The proportions of the ingredients may be varied. Thus, for the said soft bronze an additional $\frac{1}{2}$ to 1 part of bismuth may be used, taking the same quantity from the zinc, when certain large castings are to be exposed to sea water or acid fumes.

3,420 of 1877, Jensen

An alloy consists of metals mixed in or about the following proportions: 45 per cent. of silver, 30 of copper,

9 of tin, 9 of zinc, and 7 of lead. This silver alloy is as hard as forged steel, and is still malleable and will take a good polish.

For a very ductile metal, there may be used an alloy of platinum with iridium consisting of 80 to 90 per cent. of platinum with 20 to 10 per cent. of iridium. According to the degree of hardness more or less iridium is used. This alloy can be hammered and that which is more soft can be cast. It does not rust, and takes a fine polish. Its linear expansion is the slightest, and its modulus of elasticity is the least variable among metals.

5,218 of 1880, Hoper

Alloys may be produced of different classes, some possessing great hardness, density and resistance to oxidation and friction, and others having the same properties save that they are softer. They are obtained by combining 3.5 to 8 per cent. of phosphorus and from 0.5 to 15 per cent. of tin with sufficient copper to make up 100 parts in each case. To obtain great hardness, without seeking much elasticity, from 5 to 8 per cent. of phosphorus and 9 to 15 per cent. of tin are recommended. These alloys are workable and, when containing the similar specified amount of phosphorus and tin each are softer than gun metal. To produce soft alloys possessing great tensile strength and toughness 3.5 per cent. of phosphorus and from 0.5 to 5 per cent. of tin are valuable proportions.

As regards alloys chiefly to resist friction; from 4 to 5 of phosphorus and from 7 to 9 per cent. of tin are suitable in the case of friction with simple means or upon very hard surfaces; from 3.5 to 4 of phosphorus and 5 to 7 of tin may be suited for friction with irregular motion, more elasticity being here required and sometimes lead may be added in the proportion of from 2 to 5 per cent. of the total weight; from 3.5 to 4 of phosphorus; 9 to 13 of lead; 2 to 3 of tin and 3 to 5 of zinc (much copper to make up 100 parts as in each case), may be used to resist friction. In the last case the zinc is added to improve the fusion of

the high strength of lead with the other substances. The proportions of phosphorus specified should be present in the finished alloys. Numerous articles to be made of different alloys are mentioned, including pumps for acidulated or alkaline water.

3,308 of 1881, Vivian

The addition of antimony in due proportion instead of being injurious is found by the inventor to increase the strength, durability and hardness and tenacity of alloys of tin and copper with bronze. The addition of from $1/3$ to $1/5$ per cent. of antimony strengthens bronze consisting of from 93 to 96 per cent. of copper and 7 to 4 of tin, about 0.03 per cent. more antimony being added over each reduction of a unit of tin. Such bronze may be cast, rolled and drawn into sheets, wire, etc. It is malleable and ductile and resists torsion, also action of sea-water and acid solutions. It is preferred to use best selected copper and fine tin and add the antimony in the form of an alloy of copper and antimony. Such an alloy containing from 70 of copper to 30 of antimony may be made by melting the copper in a plumbago pot under a little charcoal and gradually adding the antimony. After stirring, the contents should solidify in the pot to avoid loss of antimony through pouring. The final alloy may be made by melting the copper until it reaches the boiling point indicated by the tremulous motion of a metal rod when inserted in the molted copper, then adding the tin and the antimony alloy with stirring and bringing the metal again to the boiling point. It is then taken from the furnace and stirred before pouring into the moulds which are dressed over with resin oil and charcoal dust or sometimes with tar. To cast ingots for rolling, the moulds should be a little concave to allow for shrinking of the metal in cooling and prevent the center of the ingot from being hollow. The alloy may be formed by adding tin and antimony directly to copper or copper containing antimony may be used for introduc-

ing the antimony. The best mixture found for tensile strength is: Copper, 93.81; tin, 5.95, and antimony, 0.24.

5,854 of 1882, Keep

A non-corrosive alloy of increased whiteness and uniformity in color (dispensing with the need of coating, and more easily worked than German silver, etc.), may be composed approximately of from 66 to 70 per cent. of copper, from 9.8 to 20.0 of nickel, from 0.1 to 0.5 of tin, from 0.1 to 5.0 of cadmium, and from 8.5 to 20.0 of zinc. To render the nickel more fusible and avoid loss by volatilization of the other constituents, copper is first melted and an equal quantity of nickel at a red heat is added to it. When completely melted the alloy is poured into ingots, and the percentage of each metal present may be determined by analysis. Then the alloy is again fused and more copper is added to obtain the relative proportions of copper and nickel required after which the tin, cadmium, and zinc are added in one.

Again, the alloy may comprise from 60 to 65 per cent. of copper; from 20 to 25 of manganese; 0.5 of tin; from 0.5 to 5.0 of cadmium, and from 9.5 to 14.0 of zinc. In this case ferro-manganese (containing as little iron as possible) replaces nickel in the first melting operation and the resulting melted alloy on removal from the fire is thoroughly skimmed on the surface to remove the iron as much as possible. After cooling, this alloy can be remelted, and the skimming repeated to remove any iron still present. The required alloy is afterwards made as above described. In the melting operations charcoal, borax or other material is used as a covering to prevent oxidation, and stirring is employed. A flux is used for introducing the cadmium.

3,233 of 1884, Radford

Chromium is alloyed with tin, zinc, copper, or other metals. Chrome iron, or chromium, or chrome steel are

melted and granulated by throwing them into cold water, so that they can be remelted at a low temperature. The chromium, chrome iron, or chrome steel are then mixed with a portion of the metal with which it is desired to be alloyed, covered with charcoal and melted. This is added to the larger amount of the alloying metals and the whole is well stirred and then poured into ingot moulds. By varying the proportions and the constituent metals a great variety of alloys may be obtained, including an improved white metal, which consists of the following:

Chrome iron	10	parts
Tin	10	"
Copper	10	"
Cobalt	5	"
Nickel	5	"
Zinc	60	"

Alloys to resist the action of chemical agents are obtained by combining nickel, cobalt or zinc, with any of the above alloys or compounds of chromium.

23,950 of 1895

This corresponds to U. S. Patent 578,465 on page 76.

202 of 1896

This corresponds to U. S. Patent 573,615 on page 74.

6,730 of 1898, Roman

Relates to alloys used to prevent rust and corrosion. The composition of the alloys varies from 56.8 to 90 per cent. of copper; 3 to 40 per cent of nickel; 1 to 10 per cent. of tungsten; 1 to 10 per cent. of aluminium. Alloys of a silver color are thus obtained.

21,738 of 1901, Drake

Alloys having the appearance of gold, for jewelry, wire, etc., have approximately the following composition: 954.5 parts of copper; 43 parts of aluminium, and 2.5 parts of silver. A portion of the copper may be replaced by zinc, and the other proportions slightly varied. These alloys have great resistance to corrosive influences. If the proportion of silver is increased to 5 parts per thousand, the alloy can be drawn out to a wire .003 in thickness.

6,969 of 1902, Just & Frith

A white metal suitable for gas or electric fittings, coins, vessels such as torpedoes, or torpedo boats which are in contact with salt water, and for electric resistances, etc., is prepared as follows: 54 to 67.6 pounds of copper is melted in a crucible, 12 pounds of borax and burnt sienna being added; 32½ pounds shot 1 and 1 nickel are then added, and subsequently 1 pound of iron, then 1 pound of lead, and next 1.3 pounds of tin and 26 pounds of spelter. The temperature is now allowed to fall slightly, and 1/5 of an ounce of a palladium compound, such as palladium sodiochloride, is added, followed by 3 pounds of aluminium silicate, and next by 3/5 of an ounce of aluminium vanadate. The temperature is again raised and the metal poured.

This alloy has about the color of silver and takes about the same polish. It is about as strong as mild steel. Unlike other white metals, silver included, it does not tarnish or oxidize when exposed to atmospheric influences nor is it affected by an atmosphere containing sulphuretted hydrogen or sulphurous acid. It is not affected by salt, sea or alkaline waters, or by alcoholic liquids, fats or oils, nor by fluid or vegetable acids of any kind. It has a melting point of about 980° C. It can be rolled into very thin sheets and drawn into thin tubes or very fine wire.

See British Patent No. 4,698 of 1904, page 266.

See British Patent No. 18 of 1906, page 267.

See No. 23,644 of 1902 on page 265.

9,750 of 1906, O'Brien

This corresponds to U. S. Patent 856,392 on page 10.

15,384 of 1909, Mackintosh

Alloys containing aluminium, magnesium, and nickel are made by melting the aluminium in a crucible and allowing it to cool, adding nickel oxide or hydrate and covering the contents of the crucible with magnesium oxide and a reducing agent such as carbon, heating to 1600° C., adding metallic magnesium, stirring the mixture and then casting. In a modified process, the nickel oxide, etc., is heated under a layer of a reducing agent such as carbon, which is mixed with magnesium oxide, the aluminium is then added, the mixture then allowed to cool to about 900° C., whereupon the magnesium is added, and after being stirred the alloy is cast. The crucibles employed in the process are previously coated with a mixture of carbon and magnesium oxide.

This alloy resists the action of most dilute acid and alkaline solutions.

16,177 of 1910, Duke

An alloy of a silver color is composed of the following, proportions being by volume: Copper, 24; iron, 6; nickel, 4; aluminium, 1. The addition of 0.5 to 1 part of tin makes the alloy much whiter and more resistant. The nickel is first placed in the bottom of a crucible, and the iron and copper are then respectively superimposed. The crucible is exposed to a full white heat until the iron becomes pasty, and the ingredients are mixed, when the aluminium is placed on top of the molten metals and well stirred.

This alloy resists oxidation to a remarkable degree after being dipped in strong nitric acid.

27,829 of 1911, Schmid

This corresponds to U. S. Patent 1,040,027 on page 80.

1,184 of 1912, Hatlanek

This corresponds to U. S. Patent 1,005,115 on page 79.

13,414 of 1913, Paset

Steel alloys containing 7 to 25 per cent. of chromium, 0.5 to 20 per cent. of nickel and up to 1 per cent. of carbon with or without small quantities of tungsten or vanadium, are used in the manufacture of gun barrels, turbine blades, or other articles requiring the power of resistance to corrosion. British Patent No. 23,615 of 1902 is referred to.

19,021 of 1913

This corresponds to U. S. Patent 1,077,977 on page 81.

See British Patent 8,270 of 1914 on page 229.

GERMAN PATENTS

CLASS 1-A

82,819, Roman, Aug. 13, 1895

The following alloy is absolutely resistant to acids and can be easily worked (rolled, forged, etc.). The alloy consists of aluminium, tungsten, and copper, made according to the following process:

A given quantity of tungstic acid is reduced with the use of cryolite as a flux and as soon as the bath flows thinly, enough aluminium is added to make 10 per cent. aluminium compound. A given quantity of aluminium is simultaneously alloyed with a corresponding quantity of electrolytic copper and both alloys so obtained are melted together in such proportions with pure aluminium, that the alloy does not contain less than 94 to 95 per cent. of pure aluminium. The proportion of copper to tungsten corresponds to the mechanical qualities desired.

123,750, Ekker and Kragcsics, Sept. 6, 1901

The object of this invention is a process for manufacturing an alloy having the color of nickel, which does not oxidize in the air, does not lose its polish at a temperature of 100° C., and is also completely resistant to acids.

The following is put into a crucible: 700 parts (by weight) of nickel; 1500 parts of copper; 800 parts of zinc; 8 parts of pulverized magnesium; 15 parts of cadmium; 2 parts of zinc dross; 2 parts of aluminium; 2 parts of sal-ammoniac; 2 parts of phosphor bronze. One-quarter part of the copper is put at the bottom of the crucible and then the quantities of phosphor bronze, magnesium, and nickel

are superimposed in separate layers. The second fourth of the copper is introduced, then the cadmium, then the zinc, then the zinc dross, and finally the rest of the copper. The material is then melted and the sal-ammoniac is thrown in and well mixed therewith.

133,910, Chassereau-Mourlon, Sept. 1, 1902

An exceptionally resistant and difficultly oxidizable alloy which is a good conductor of electricity and can be easily soldered, consists of 900 parts of aluminium; 50 parts of bismuth; 25 parts of iron, and 25 parts of nickel. The nickel gives the product great resistance against oxidizing influences, while the bismuth renders the melting of the alloy more easy. The various constituents can be melted together.

123,820, Berg, Sept. 10, 1901

This is an addition to German Patent 82,819, and according to this invention some zinc is added to the alloy of this former patent. A given quantity of tungstic acid is reduced with the use of cryolite as a flux, and as soon as the bath flows thinly enough aluminium is added to make a 10 per cent. aluminium alloy. A given quantity of aluminium and a corresponding quantity of electrolytic copper to which a given per cent. of zinc has already been added, are simultaneously alloyed, and these two alloys are melted together in such proportion that the alloy does not contain less than 91 to 92 per cent. of pure aluminium. The amount of aluminium varies between 2 to 7 per cent., according to the different qualities desired.

123,919, Ekker and Kragesics, Sept. 10, 1901

This alloy has a silver color, is malleable and ductile, does not oxidize in the air, does not lose its polish at a temperature of 100° C., and besides is completely resistant to acids. The following are placed in layers into a crucible, in the order mentioned: 600 parts of nickel; 2,000 parts of

copper; 400 parts of zinc; 10 parts of powdered magnesium; 30 parts of cadmium; 2 parts of zinc dross; 1 part of aluminium; these constituents are then melted together, well mixed, and then intimately mixed with 1 part of sal-ammoniac.

243,663, Borchers and Barth, Feb. 17, 1912

A cobalt-tin alloy having about 40 per cent. of cobalt and 60 per cent. of tin has an extraordinary resistance to acids, even against nitric acid in all its concentrations, and even when the acid has impurities such as sodium chloride.

As this alloy is brittle and is almost unsuitable for mechanical working, this discovery in itself is of slight practical value. If, however, this alloy is mingled with another metal that is more easily worked, as for example, copper, an increased chemical resistance is imparted to this metal. If, for example, alloys are made which contain between 80 to 90 per cent. of copper and from 20 to 5 per cent. of the before mentioned cobalt-tin alloy, then alloys are obtained which can be very well worked, and at the same time have high resistance against chemical influences. These alloys are so slightly attacked by dilute nitric acid that from 5 to 7 years would be required to dissolve a layer 1 mm. thick. In reality the speed of solution is even less. These alloys can be manufactured by the customary methods. It is preferable, however, to first make the first mentioned cobalt-tin alloy and then dissolve this in the copper.

246,035, Borchers and Monnartz, April 22, 1912

This invention relates to an iron alloy that unites high chemical resistance together with workability. It has already been proposed to make objects which must resist the action of acids and mixtures of acids, out of a chromium-iron alloy. These alloys, however, do not have a sufficient resistance to acids even when they contain a large amount of chromium. If the acids and acid solutions con-

tain too large an amount of chlorides, as, for instance, more than 5 per cent. of the alkali chlorides and the products thereof with other acids, and especially if oxidizing acids (like nitric acid) are present even only in small quantities (as for example, 2 per cent. or even less of nitric acid), then these alloys become finally soluble.

An alloy that can resist acids and mixtures of acids of all kinds and then can be mechanically worked, is secured if from 2 to 5 per cent. of molybdenum is added to an iron-chromium alloy having more than 10 per cent. of chromium, and either free from carbon or containing relatively small quantities of carbon. For example, an alloy which consists, besides some non-essential constituents, of 60 per cent. of chromium; 35 per cent. of iron and 2 to 3 per cent. of molybdenum, can be readily worked, and is completely insoluble in dilute nitric acid (2 per cent. nitric acid and even weaker) even in the presence of many alkali chlorides, and even in boiling aquaregia. Vanadium and titanium have the same effect as molybdenum, but are not so favorable in their action.

255,919, Borchers and Borchers, January 23, 1913

This invention relates to nickel alloys which have a high chemical resistance together with good mechanical workability.

From the known properties of nickel and of chromium and of nickel chromium alloys, high chemical resistance of such alloys is to be expected especially against acids which can produce the known condition of passivity in a number of metals, as for example, nitric acid. Nickel alloys containing 25 per cent. of chromium and upwards show a very high chemical resistance, but suffer from the defects that they cannot be easily forged, rolled, or otherwise mechanically worked. In order to obviate this evil without lessening the chemical resistance of the alloy, silver has been found suitable, contrary to all expectations. Only a slight addition of silver can be made because of the limited solubility of the silver in nickel and chromium, but

this slight amount of silver increases the workability of the nickel chromium alloys to a striking degree. The chemical resistance does not suffer because of the silver, but is even increased, which was not to be expected because silver has a high solution tension in nitric acid and is not one of the metals that can be rendered passive. An alloy that is especially resistant to nitric acid is made up of the following: 30 per cent. of chromium; 1.5 to 2.5 per cent. of silver, the rest being nickel.

256,123, Borchers, Jan. 30, 1913

This relates to a nickel alloy which has a high chemical resistance as well as good workability. It is to be expected from the known properties of nickel and cobalt, and nickel cobalt alloys, that these alloys would have a high chemical resistance against nitric acid of such a concentration that it could produce the phenomenon of passivity in these metals. Still, the condition of passivity in nickel and cobalt, and nickel cobalt alloys in dilute nitric acid is less easily maintained than with corresponding iron and chromium alloys. It is true that nickel alloys having more than 50 per cent. of cobalt, especially one having 60 per cent. of cobalt, has a maximum resistance against dilute nitric acid, even if it contains a chloride. Such alloys, however, cannot be easily forged, rolled or otherwise mechanically worked. A slight addition of silver increases the workability. Silver can only be added in slight amounts, but increases the workability of the nickel-cobalt alloys to a striking degree. Still more striking is the phenomenon that a small addition of silver increases the chemical resistance of the alloy, especially when it is considered that silver has a high solution tension in nitric acid and does not belong to the metals that can be rendered passive. Nickel alloys having more than 50 per cent. of cobalt, preferably having about 60 per cent. of cobalt, upon the addition of less than 1 per cent. of silver, preferably about 0.4 per cent. of silver are readily worked and are so resistant that they are scarcely attacked by strongly diluted nitric

acid even in the presence of chlorides, such as sodium chloride.

256,361, Borchers and Borchers, Feb. 6, 1913

This is an addition to German Patent 255,919. It has been found in the nickel alloys mentioned in this patent the nickel can be partially replaced by a like weight of cobalt, and the silver can be entirely or partially replaced by a larger weight of copper, at the highest by a double weight. These alloys so obtained still possess good mechanical workability and the chemical resistance of the alloys mentioned in No. 255,919.

257,380, Borchers, Feb. 27, 1913

This is an addition to German Patent 256,123. It was seen in this patent that nickel cobalt alloys become more resistant to nitric acid by the addition of the easily soluble silver. It was hardly to be expected that copper which has even a higher solution tension than silver in nitric acid would make the alloy mentioned in No. 256,123 even more resistant than silver. It has now been found that the addition of copper up to 15 per cent. produces even more resistant alloys than those mentioned in No. 256,123, especially in those nickel alloys which as mentioned in No. 256,123 contain more than 50 per cent. of cobalt, preferably 60 per cent. of cobalt, and received an addition of copper up to 15 per cent., either with little silver or without any silver at all. It is preferable that the copper should be about 2 to 5 per cent. of the weight of the nickel-cobalt alloy.

265,076, Borchers and Borchers, Sept. 30, 1913

This is an addition to German Patent 256,361. It has been discovered that in spite of a considerable lessening of the amount of silver and copper of the alloys mentioned in No. 256,361, the resistance of these alloys is not injured, but is even increased by substituting a small quantity of

molybdenum, for the silver and copper. Neither is the workability diminished.

According to this new invention the addition of silver and copper can be lessened to about 3 per cent. of the alloy and the acid resistance is substantially increased if the silver or copper which has been removed is replaced by molybdenum to the amount of from 0.5 to 5 per cent. of the alloy.

265,328, Borchers and Borchers, Oct. 7, 1913

This is an addition to German Patent No. 255,919. The chemical resistance of the alloys mentioned in the former patent is increased by substantially lessening the amount of silver and replacing the silver so omitted by a small quantity of molybdenum. The chemical workability of the original alloy is not lessened. According to this invention the amount of silver added can be lessened to less than 0.3 per cent. of the alloy and the resistance to acids is substantially increased, if the omitted silver is partially or completely replaced by molybdenum to the amount of from 0.5 to 5 per cent. of the alloy.

268,516, Borchers and Borchers, Dec 18, 1913

This relates to an improvement on German Patent 265,328. It has been discovered that the alloys mentioned in this patent are not injured to any noticeable extent if a part of the nickel is replaced by iron which is cheaper. According to this invention practical alloys can be secured if iron replaces the nickel in these alloys, up to 90 per cent. of nickel.

This invention offers the further advantage that absolutely pure nickel is not necessary for the manufacture of these alloys. On the contrary, nickel containing a large quantity of iron can be used.

277,242, Siemens-Halske, Aug. 5, 1914

The manufacture of tantalum is very difficult as there always is a danger that the alloys will be brittle.

Tantalum alloys have up to the present been of no practical significance. It has, however, been discovered that it is possible, by adding tantalum to nickel, especially relatively small amounts of tantalum, to so affect the nickel that a very valuable and very special product is produced. An alloy of nickel with from 5 to 10 per cent. of tantalum shows very striking properties, especially with reference to resistance to acids, and ductility. An acid with 30 per cent. of tantalum may be boiled as long as is desired in aquaregia and other acids without any change being suffered. This alloy is very ductile, can be easily rolled, hammered and has a strength which is equal to that of the best steel, or even exceeds it. For example, a wire of $\frac{1}{2}$ mm. diameter has a tensile strength of more than 200 kg. per sq. mm.

Aside from this the nickel has completely lost its magnetic properties. Its elasticity is like that of the best steel. It can be heated to very high temperatures in the atmosphere without oxidizing. To be sure the alloy may become brittle if very strongly heated.

To manufacture these alloys it is preferable not to directly melt the material in the electric arc. It is much better if the material is laid into a crucible or into a quartz tube, and then heated from without to a high white heat. The material is preferably well mixed together in powdered form for this purpose, pressed together to a coherent body under high pressure and then introduced into the crucible, tube or the like.

The heating can take place by means of an electric arc formed, for example, between tantalum electrodes or by means of an electric arc formed between a tantalum electrode and a nickel electrode, which serves as a foundation.

The heating can take place by electrical resistance as for example by surrounding the tube or the crucible with granulated tungsten or tantalum and leading an electric

current through this. The heating preferably takes place in an inert atmosphere and even better in a vacuum.

The tantalum nickel alloy can be used for tools, medical instruments, vessels for chemical purposes, writing pens, springs or the like.

277,855, Grohmann & Co., Sept. 3, 1914

The object of this invention is an alloy containing iron and silicon to be used for the manufacture of vessels resistant to acids at high temperatures, especially those for chemical industries, as well as for armatures, pipes and the like. It is known that iron is rendered resistant to all acids, with the exception of hydrochloric acid and fluoric acid, by the addition of silicon. The amount of silicon that can be added is limited by the brittleness and the difficulty in working such alloys. It has been proposed to make such alloys more easily worked by adding metals such as manganese, nickel, lead, and the like, but the problem was not satisfactorily solved because the resistance to acids was affected.

It has now been discovered that an addition of chromium to the silicon-iron alloy gives it exceptional workability without lessening the resistance to acids. On the contrary the addition of chromium favorably affects the resistance to acids. Alloys that contain up to 18 per cent. of silicon and at the most, up to 70 per cent. of chromium can be used. They are completely acid resistant, for example, against sulphuric acid. It is not to be foreseen that an alloy which would contain high percentages of chromium and silicon would be workable. This discovery has the important technical result that objects can be made that are distinguished by a special resistance to acids of high temperatures.

278,902, Borchers and Borchers, Oct. 2, 1914

This is an addition to German Patent 265,076. It has been found that the molybdenum can be partially or completely replaced by one or more of the following metals:

Gold, the metals of the platinum group (platinum, iridium, osmium, palladium, rhodium, ruthenium), and tungsten, without harming the chemical properties of the alloys. This is of practical importance because it is already difficult to purchase molybdenum.

278,903, Borchers and Borchers, Oct. 21, 1914

This is an addition to No. 265,328. It has been found that the molybdenum can be partially or completely replaced by one or more of the following metals: Gold, the metals of the platinum group (platinum, palladium, iridium, rhodium, ruthenium), and tungsten, without injuring the chemical properties of the alloys. This is of practical importance because it is already difficult to purchase molybdenum.

GERMAN PATENTS

CLASS 1-B

33,102, Mouchel, Sept. 16, 1886

For many purposes it is desirable, without essentially changing the special qualities of copper and its alloys to give them either a greater ductility, greater hardness, and a greater resistance to acids. For this purpose the copper or its alloys has added thereto either pure chromium or its compounds. It makes no difference in what manner the chromium is introduced into the copper and its alloys, and the ductility or hardness of the chromium-copper alloy depends upon the proportions of the chromium which is added.

If the copper chromium alloy is made of pure materials it can be made most simply in a crucible or a suitable furnace. Chromium and copper or the alloys of these metals are brought together in the quantities chosen for the purpose desired, and they are melted with constant stirring, until the mixture has been made uniform. Instead of simply melting together pure metals, their oxides or similar compounds can be brought together in a furnace and be reduced in the presence of carbon or other reducing means.

The melting together of the pure metals in a crucible is preferable as it enables better control of the operation.

If it is desired to have a chromium copper metal that should be a good conductor of electricity the addition of chromium must be made as small as possible. Even a slight addition gives a much greater ductility than that of pure copper or its alloys, and besides the chromium copper metal can be worked much more easily than pure copper.

If it is desired to have a hard alloy which is little worn out by friction the amount of chromium added must be increased and a chromium copper alloy is then secured, which is not appreciably attacked by fuming nitric acid, and is so hard that it can scratch glass.

All degrees of hardness between these two limits can be secured by correspondingly choosing the amount of chromium added.

66,937, Solvisky, Jan. 20, 1893

An aluminium alloy which has great resistance to oxidation is made by adding nickel (or cobalt) as well as cadmium. The first increases its hardness and the second its ductility.

Since the nickel or cobalt can only be alloyed with aluminium imperfectly and with difficulty, they are added in the form of a tin alloy, which has a melting point as near as possible to that of aluminium. Thus 50 parts of nickel and 50 parts of tin have a melting point of about 800° C. Some of the alloys are as follows: Aluminium, 90 per cent.; nickel, 1 per cent.; tin, 5 per cent.; cadmium, 4 per cent. This has about half the hardness of iron. Another alloy is as follows: Aluminium, 95 per cent.; nickel, 1 per cent.; tin, 1 per cent.; cadmium, 3 per cent. The aluminium and the nickel alloy are first melted together, and then the cadmium is added either in the pure condition or in the form of a cadmium alloy.

54,846, Held, 1890

This discloses a process for producing an alloy which does not oxidize or lose its gold color even if subjected for a long time to the action of air containing ammonia and acid fumes, which can be rolled and worked like gold and has the appearance of genuine gold.

This alloy consists of 100 parts of copper and 6 parts of antimony. The copper is melted and as soon as it has reached the required temperature the antimony is added.

When the antimony is also melted and intimately combined with the copper, some magnesium and lime-spar are added thereto.

This addition gives the cast metal a high density. It can be rolled, forged, hammered, soldered, and polished.

146,985, Vogt and Cie, November 23, 1903

Experiments made with aluminium bronze have shown that by adding lead and manganese to aluminium bronze an alloy of special hardness, strength and resistance to acids can be obtained, that can replace the ordinary rack metal. The racks made out of this alloy are superior to those made of steel in that they are much more acid-resistant while their hardness and elasticity are similar.

This alloy is made up as follows: Copper, 86 to 89 per cent.; aluminium, 12.5 to 7.5 per cent.; lead, 1 to 2 per cent.; manganese, 0.5 to 1.5 per cent. This alloy is made as follows: The copper is melted and refined. Then the necessary amount of phosphorus, 0.5 per cent., is added in the form of phosphor-copper, and then the lead and the aluminium are added. Then the manganese is added to the liquid mass before it is poured out.

190,234, Schumacher, Oct. 8, 1907.

An alloy to resist the detrimental influence of acids is made of $49\frac{1}{2}$ per cent of nickel, $49\frac{1}{2}$ per cent. of aluminium, and 1 per cent. of phosphorus.

PREFACE TO CLASS 2

Under this heading will be found all the alloys having the same coefficient of expansion as glass and particular attention is called to U. S. Patent 626,609, in which the theory of a nickel-iron alloy serviceable in leading in wires for incandescent lamps, has been completely worked out.

Besides patents on alloys we have included herein the important patents relating to coating wires with platinum, etc., for this purpose, and other inventions relating to leading-in wires not based on alloys.

The fundamental idea of most of these patents is shown in the expired U. S. Patent 626,609, which discloses the nickel-iron alloys which are most frequently used. British Patents 21,881 of 1899, and 24,918 of 1904, disclose additional improvements in connection with these alloys. In particular British Patent 24,918 of 1904, discloses coating of the nickel-iron alloy with an alloy of silver and platinum. Some of the basic ideas connected with this class are therefore open to public use.

U. S. PATENTS

CLASS 2

626,609, *Guillaume and Dumas, June 6, 1899*

Alloys of nickel and iron expand or contract under the influence of heat, in accordance with laws which are peculiar to such alloys, and which generally are very different from the laws governing the expansion and contraction of iron or nickel separately.

Numerous experiments have shown that by varying the proportions of nickel and iron in the alloy, products are obtained whose coefficients of expansion vary within considerable limits. When the proportion of nickel is less than about 20 per cent., the coefficient of expansion lies between that of iron and that of nickel; but this coefficient of expansion increases when the proportion of nickel is raised, until with 22 to 24 per cent. of nickel, it closely approximates that of brass, when it attains its maximum. The coefficient of expansion then progressively diminishes, with further increase of nickel until it is practically nil when the content of nickel reaches about 37 per cent. Beyond this proportion the coefficient of expansion again increases and becomes approximately equal to that of platinum when the proportion of nickel reaches 45 per cent. The coefficient of expansion of ferro-nickel alloys thus varies between a maximum and a minimum, the minimum being zero or approximately zero, and this minimum expansion being attained by alloying about 37 per cent. of nickel with the iron. The alloys produced in accordance with this invention may contain, besides iron and nickel, varying quantities of the metals and metalloids which ordi-

narily enter into the composition of steel. By making certain elements of apparatus of non-expandible alloy, systematic tension or deformation may be produced which is much greater than has hitherto been possible. As examples, there may be mentioned bimetallic thermometers, the expansion plates of the thermal variation thermometers, fire alarms, and compensators.

The non-expandible alloy may be mixed in suitable proportion with other metals or alloys for the production of alloys having the same expansion as the other substances with which they are combined or connected, such as glass, crystal, etc., and this will be of particular advantages for the manufacture of incandescent lamps, Crookes' tubes and the like, spectacle frames, mirrors and optical instruments in general.

See U. S. Patent 824,618 on page 158.

*1,043,577, Eldred (Assigned to Commercial Research Co.),
Nov. 5, 1912*

To form a compound body having a foundation of iron, steel, or other metal of high melting point, and a facing of platinum, the foundation metal is heated to a temperature approximating the melting temperature of platinum and is then cast to solidify against the platinum surface. An apparatus is described for preventing the presence of a film of air, etc., between the two metals. This is accomplished by placing the platinum in a mould full of molten flux, and pouring the molten foundation metal into the mould. The flux displaced flows out through gutters. An iron wire coated with platinum and produced by this process, is suitable for use as a leading-in wire.

If it is desired to impart superficial porosity to the platinum it may be superficially corroded by reacting gases, or it may be wetted with a solution of a platinum salt and then heated.

I claim:

1. The process of producing compound bodies of unlike metals welded together comprising a metal of a melting point above 2900° F., and a ferrous metal having a melting point below 2900° F., which consists in contacting with a body of such metal of extremely high melting point a molten body of the other said metal heated to a temperature approximating the melting point of such high melting point metal, and permitting the molten metal to solidify against the surface of such high melting point metal.

See U. S. Patent 1,043,576 on page 303.

*1,043,578, Eldred (Assigned to Commercial Research Co.),
Nov. 5, 1912*

To make a compound body having a platinum surface, a platinum tube highly heated is placed within a highly heated mould, and a suitable quantity of molten gold, silver or copper is poured therein. A ferrous billet having a welded-on coating of copper or like metal, applied, for instance, according to U. S. Patent 853,716, is now introduced under non-oxidizing conditions, and the linking metal is allowed to solidify.

Platinum coated iron wire produced by drawing down a platinum iron billet produced as above described, is particularly suited for use as a leading-in wire.

For this purpose, the core may be made of nickel steel. The superficial porosity of the platinum may be increased for catalytic purposes, by suitable gas, or wetting it with a solution of a platinum salt and then heating.

I claim:

1. The process of producing compound metal bodies, comprising a metal of the platinum group and an unlike metal of lower melting point inseparably united which consists in bringing into proximity a heated body of a plati-

num metal and a heated body of an unlike high-melting metal to be united thereto, and bringing into the space between them a molten body of high-melting metal capable of uniting with both such metals and permitting the molten metal to solidify.

1,078,906, Eldred, Nov. 18, 1913

This is directed to making compound metal bodies having a core of iron, steel, or iron-like metal firmly united to a sheath of copper or copper-like metal by an intermediate linking layer of metal.

This is useful in copper-clad material for electric conductors, gold-clad and platinum-clad metal for toothpins, leading-in wires, etc.

The core is filmed with copper or brass in any way, as by galvanic means. The coated body is washed and dried to free it from acid, oxidation being avoided. It is next coated with a thin coating of a fusible mineral as borax or zinc chloride. This coating may be applied in solution and the solution dried in place.

The flux-coated billet is introduced into a sheath of the coating metal, as copper, platinum, or gold. This sheath should be nearly red hot, and snugly fit over the core when in this condition.

The assembled core and sheath are now heated, the core expanding and pressing against the shell. The heating may be carried to the softening point of the coating metal.

The compound billet may be worked in the hot or cold condition.

I claim:

1. The process of producing clad metals which comprises coating a relatively stiff metal core with a softer metal, placing said core in a relatively cool condition within a heated and expanded shell of a high-melting, ductile non-ferrous metal, and heating to cause said core to expand against said shell and produce a union.

1,083,070, Eldred, Dec. 30, 1913

This relates to a composite leading-in wire having a platinum coating. This wire has a coefficient of expansion less than that of platinum. The core is made of nickel-steel or other low expansion high-melting alloy or metal. A nickel-steel having a rate of expansion of about 0.0000025 up to 100° C., is preferred. A nickel-steel having about 38 per cent. of nickel is satisfactory. To regulate the expansion of the core, it is coated with copper, silver or gold or their alloys, and with an outside sheath of platinum.

The nickel-steel core has an alloy of copper welded on according to the method disclosed in U. S. Patent 853,716 or 1,217,581. This is then turned in a lathe, inserted in a closely fitting platinum tube and heated until the layers are united. The billet may then be drawn into wire and annealed.

I claim:

1. An article of manufacture comprising a wall of glass having sealed therethrough a wire of high-melting metallic material, said wire being of a rate of expansion materially less than glass and being held in the glass under compressive strains in the union therebetween.

1,093,557, Gleason (Assigned to Neu-Metals and Process Company), April 14, 1914

It is the ultimate object of my invention to provide boiler and condenser tubes of homogeneous metal capable of resisting corrosion, but my improved alloy is not only capable of resisting the corrosive action of water and steam, but is also capable of resisting the action of sulphuric and nitric acids and other corrosive liquids, and consequently may be employed for other structures than such tubes. Said alloy is about the color of platinum and has a coefficient of expansion, by heat, approximately that of glass. I find that the useful properties aforesaid are characteristic

of alloys within the following range of proportions by weight.

Iron	80 to 120 parts
Nickel	80 to 120 parts
Copper	1 part
Aluminium	4 parts

I find it preferable to employ Swedish iron in making such alloys and a typical example, having the useful properties above stated, is as follows:

Swedish iron	110 parts
Nickel	90 parts
Copper	1 part
Aluminium	4 parts

It is to be noted that ordinary alloys including iron-nickel-copper are objectionable in that casting and cooling the same usually results in separation of said metals and formation of hard nodules throughout the mass of the alloy. Consequently, it has been the practice hitherto to include in such alloys manganese, magnesium, or some other deoxidizing agent, and more or less carbon; the strength of such ordinary alloys being apparently dependent upon the amount of carbon retained therein. However, alloys within the proportions above stated may be made without the inclusion of the deoxidizing agents aforesaid, and without regard to carbon and are not only homogeneous, but are so ductile that they may be readily rolled to sheet or drawn to tube and wire forms.

Alloys in accordance with my invention do not require any special method or means of manufacture, and ordinary methods and means may be employed.

I claim:

1. An alloy comprising iron, 80 to 120 parts; nickel, 80 to 120 parts; copper, 1 part, and aluminium, 4 parts.
2. An alloy comprising Swedish iron, 110 parts; nickel, 90 parts; copper, 1 part, and aluminium, 4 parts.

1,140,134, Eldred, May 18, 1915

This relates to a composite leading-in wire having a ferrous-nickel core and a sheath of platinum, silver, gold, or copper.

The sheath and core may be combined according to U. S. Patent 853,716. The core is preferably made of nickel-iron having a smaller coefficient of expansion than the glass.

Thus, if the glass has an average coefficient of expansion of about 89 or 90×10^{-7} , the core should have 38 to 45 per cent. nickel, so that its average coefficient of expansion is 42×10^{-7} to 77×10^{-7} . The sheath, if of silver, should be about 65 per cent. of the weight of the billet or core, if of copper, about 60 per cent., if of gold, about 75 per cent.

The billet is then worked down to wire, usually 0.006 to 0.015 inch diameter.

With a lamp having glass having an average coefficient of expansion of say 89×10^{-7} from common temperatures up to 300° C., the leading-in wire may have an average coefficient of expansion lying between 60×10^{-7} and 75×10^{-7} for temperatures up to 300° C. A tight joint is produced by the pressure between the glass and wire. Such a wire has a core containing 38 per cent. nickel.

I claim:

1. The combination, with a gas-tight receptacle having a wall of vitreous material, of a composite leading-in wire sealed therein, said wire comprising a core of metallic material having a coefficient of expansion whose average from the setting temperature of the glass down to normal, is less than that of the glass through the same range of temperatures, said wire having an external metallic sheath consisting of a metal of high electrical conductivity, said sheath having a coefficient of expansion whose average for said temperature range is greater than that of said glass, the said sheath being united to the core to give a resultant

average of expansion of the wire for the said temperature range, such that a union may be made and maintained between said sheath and the glass.

*1,140,135, Eldred (Assigned to Commercial Research Co.),
May 18, 1915*

The description is substantially the same as No. 1,140,134.

I claim:

1. The process of producing a composite metallic body with a predetermined coefficient of expansion, which consists in uniting a sheath of one kind of metallic material to a core of a different kind of metallic material, the core and sheath having different coefficients of expansion, one being greater and the other less than the required predetermined coefficient of expansion, the thickness of the sheath being so adjusted relative to the size of the core as to give to the composite metallic body a resultant coefficient of expansion substantially that determined.

*1,140,136, Eldred (Assigned to Commercial Research Co.),
May 18, 1915*

This invention relates especially to leading-in wires for lamps, although this invention may be applied also to other uses, and it includes as a new article of manufacture a composite wire or sheet having a core or layer of a low-expansion metal or alloy firmly united to a layer of high-expansion metal of high conductivity, the relative thickness of such layers and the relative expansions of the metals thereof being so correlated that the composite wire or sheet as a whole shall have a compound regular rate of expansion, such rate of expansion being below and advantageously materially below, that of platinum or ordinary glass; that is, materially below an average rate of expansion of 0.0000089 or 0.0000090 for each centigrade degree of change in tem-

perature through the sealing-in range and below, say, from about 300° to normal temperature; such composite wire advantageously having a core of nickel-steel of proper low expansion and an external sheath or layer of copper or silver; all as more fully hereinafter described and as claimed.

The invention also includes a method of producing wire as fully disclosed and claimed hereinafter.

In the manufacture of incandescent lamps it has heretofore been the practice to use platinum leading-in wires for conveying the current from an exterior source to the filament within the lamp bulb. Platinum has been employed for this purpose because of certain characteristics which render it particularly suited for the purpose and which have been heretofore regarded as practically indispensable in a leading-in wire. Among these characteristics may be mentioned (1) its relatively low coefficient of expansion, which is nearer than that of any other pure, high melting metal to the coefficient of expansion of glass; (2) its peculiar superficial affinity for molten glass whereby its surface is actually wetted by molten glass; and (3) its unoxidizability, which insures the maintenance of a clean metallic surface throughout the heating operations involved in making lamp seals.

The thermal coefficient of expansion and contraction of platinum, is generally stated to be from about 0.0000089 to 0.0000091 for each centigrade degree change in temperature. The thermal coefficient of glass is always somewhat below that of platinum, and with many types of glass it is very much below that of platinum. Glass can be produced, however, having at temperatures, say, below 100° C. an expansion as high as 0.0000081, rising to 0.0000087 to 0.0000088 at temperatures around 300° C. A union can therefore be formed with platinum at the softening point of such glass which will in most cases persist. The tendency of the platinum, which contracts more than the glass on cooling, to shrink away from the glass, is resisted by the mechanical strength of the union formed with the soft-

ened glass. In the cooled lamp the layers of glass next the wire are, however, under tension, and this may produce cracks and air leaks. Much, however, depends on the thickness of the wire; thin wire being safer in this respect than thick.

All high melting metals other than platinum have a still greater thermal rate of expansion and consequently it has not been feasible to employ such metals alone as leading-in wires, for the obvious reason that the tensile stresses between such wires and the glass would be so great as to destroy the seal. Furthermore, the tendency of metals, such as iron, to oxidize readily especially under the high temperature conditions obtaining in lamp manufacture has rendered it practically impossible to keep the surface of such leading-in wires clean. With most metals, porous oxide layers are formed and the formation of an air-tight joint with the glass has been prevented. Further, since platinum leading-in wires in practice must be made exceedingly thin, both for the sake of economy and to reduce the strain in the metal-glass union, the conductivity is not good. Platinum is a relatively poor conductor. In my application No. 790,467 I have disclosed and claimed a compound wire having a platinum surface, a low-expansion nickel steel core and an intermediate linking layer of copper or silver, the wire as a whole having an expansion below that of platinum; and in my application No. 656,987 I have claimed such a wire in connection with a glass article in which it is sealed. This type of leading-in wire has proved eminently satisfactory in practice; but it is to be noted that it involves the use of a platinum surfaced leading-in wire. It has been considered necessary to have platinum in contact with glass in order to secure a perfectly satisfactory union or seal between the wire and the glass. The present invention is directed to an improvement over the leading-in wire specifically claimed in the said applications, whereby the use of the expensive platinum sheath may be done away with if certain conditions, hereinafter to be more fully described, are carefully observed.

In experimenting with leading-in wires of the general type of said prior applications, that is, with leading-in wires having a regulated coefficient of expansion below that of the glass into which they are to be sealed, I have discovered that if the coefficient of expansion of the wire be carried sufficiently far below that of the glass employed at temperatures involved in the sealing operation to cause absolute contact by compressive forces, it is not necessary to employ platinum for contacting with the glass, as has heretofore been generally considered indispensable. Under the conditions just mentioned, the glass during the cooling down from the sealing-in temperature exerts a strong positive pinch or compression on the sealed-in wire, this compression causing the glass to be in extremely intimate contact with the surface of the leading-in wire, with the result that a tight seal is formed, amply sufficient to maintain the requisite degree of vacuum in the lamp bulb at all times. When the glass is hot, it is, of course, quite plastic and can shrink into absolute conformity with the wire surface. By choosing a high melting, low expansion alloy, such as certain alloys of nickel and iron, a leading-in wire can be made to have a rate of expansion as much less than that of the particular glass in question as may be desired. These nickel-iron alloys have a lower expansion than either iron or nickel alone. Although such alloys are, of course, more or less oxidizable, the formation of oxide to a reasonable extent on a surface of the wire during the formation of the seal does not interfere with the production of an air-tight union with the glass, this being due to the fact that the surface of the joint is so tightly compressed by the surrounding glass during the sealing-in operation as to cause a perfect joint. It is, of course, feasible also to perform the sealing-in operation in an inert atmosphere of hydrogen, nitrogen or the like if it is deemed desirable to prevent oxidation altogether, in which event such a strong compression of the glass on the wire is not required.

While it is possible to obtain good seals with leading-in wires of nickel-iron alloys, such alloys when used alone

have certain drawbacks, among which may be mentioned particularly their irregular rate of expansion through the range of temperatures involved in making lamp seals. The expansion curve for nickel-steel alloys of the low expansion types here in consideration is rather irregular and is by no means rectilinear between temperatures of 0° and 325° C., the latter temperature being approximately the highest temperature involved in making lamp seals, that is, about the temperature at which lampglass sets to its hardened state from its softened or plastic condition. The particular nickel-steel alloy corresponding to the curve contains about 38 per cent. nickel. In making wire for lamp purposes, I have found it advantageous, therefore, to provide a low expansion nickel-iron alloy core with a sheath of another high melting metal whose rate of expansion, although much higher than that of glass or of the core, is nevertheless substantially uniform over the range of temperatures in question. In this way, the irregular expansion curve of the nickel-iron alloy may be forced, so to speak, to assume much greater uniformity. That is, the compound wire, as a whole, has a compounded rate of expansion materially more uniform than that of the nickel-iron alloy, although somewhat less uniform, of course, than the high expansion sheath. By selecting a nickel-iron alloy of sufficiently low thermal expansion and combining a core of this alloy with a regulating sheath of high expansion metal of the proper relative dimensions, the compound leading-in wire as a whole may be given any combined or average coefficient of expansion desired, which may be as much less than that of the particular type of glass to be used as may be desired. Various high melting metals, excluding platinum, may be employed to give this forced or regulated rate of expansion through the range of temperatures involved in lamp making to the compound leading-in wire. For most purposes, however, I find a regulating sheath of copper to be most satisfactory and this is especially desirable for leading-in wires, on account of the high conductivity of copper. Such copper sheath may be

united to the nickel-iron core integrally as by a weld-union produced in accordance with the process described in the United States Patent to Monnot, 853,716. Better results, however, may be attained in another method of weld-uniting hereinafter more specifically described. Where the sheath and core are weld-united in this manner, the regulating effect of the copper sheath in straightening the expansion curve of the wire as a whole and forcing it to approach rectilinearity is most effective.

While the integral union between the copper sheath and its supporting core is a distinct advantage for the reasons specified, I do not desire to be limited to the use of such a bimetallic wire. A union effected by soldering or hammering, hot swaging, etc., may be used, but is more liable to be defective and such defects may only be disclosed when the finished lamp is tested. Since, however, a leading-in wire under the present invention may be made so as to be strongly compressed by the glass into which it is sealed, during the sealing-in operation the weld union between core and sheath is not absolutely indispensable, although it is much to be preferred.

In addition to straightening out and reuderer more nearly uniform the expansion rate of the leading-in wire, the copper sheath has the additional function of materially increasing its conductivity. Nickel-iron alloys have a conductivity relatively low as compared with copper. This second function of the copper sheath is therefore an extremely important and advantageous one. In this compound wire the copper gives conductivity and the nickel-steel strength and low expansion; and, in a way, the wire may be regarded as a reinforced, low-expansion copper wire.

Instead of using copper for the sheath, either silver or gold may be employed, both metals being good conductors and the rates of expansion of both of these metals being much more uniform than that of nickel-iron alloys, although considerably higher than that of glass or of platinum. Nickel, iron, or any other high melting metal having

a relatively high, but sufficiently uniform coefficient of expansion, may also be used for the sheath under some conditions. The highly conductive metals of the copper class, copper, gold and silver are, however, better. The nickel-steel of the core is not highly conductive and pure metals of the iron class are not much better. Use of metals of the copper class as one layer is, therefore, much more advantageous.

With glass having a coefficient of expansion of, say, 0.0000087 from common temperatures up to 300°C. , it is advantageous to employ a leading-in wire having an average coefficient of expansion lying between 0.0000060 and 0.0000075 within the same range of temperature. With a leading-in wire of this description the pressure existing between the wire and glass in the seal is sufficient to insure a permanently tight joint; and at the same time, this pressure is not so great as to require the use of thicker or more massive lamp stems than are ordinarily employed in present practice. By increasing the size of the lamp stem its strength (to withstand stress) may be correspondingly increased, permitting the use of leading-in wires having much lower coefficients of expansion than that above mentioned; and under some circumstances this may be desirable. Of course, where glasses of lower expansion coefficients are to be used, the leading-in wire should have a correspondingly lower coefficient of expansion. In this connection, it is to be understood that by suitably varying the proportions of nickel and iron in a nickel-iron alloy, an alloy having practically any desired average rate of expansion is obtainable, the upper limits being those of the individual metals while the lower limit may be carried down very low and may be made substantially zero for temperatures not over 100°C.

In a typical embodiment of the present invention in its most advantageous form, I may use a nickel-iron alloy containing, say, 38 per cent. nickel and having an average coefficient of expansion up to 100°C. of about 0.0000025. A billet of this alloy may be provided by any suitable method

with an outer layer or sheath of copper. This layer may then be turned down in a lathe to the exact thickness required to correct the expansion curve of the nickel-iron alloy and to give the requisite degree of uniformity in the rate of expansion in the complete leading-in wire. The billet may then be drawn or swaged to wire and annealed. In practice, the billet or rod of nickel-iron alloy may be 0.892 inch in diameter, and after the copper layer is attached thereto, the assemblage may be turned down to a cylinder of 1 inch diameter. In the finished wire resulting from drawing down the billet, the total diameter may be, say, .008 to .015 inch in diameter, the thickness of the copper layer being advantageously about 0.00005 inch. The foregoing dimensions are to be understood to be illustrative only and as capable of considerable variation.

In producing the article, I find it advantageous to use a vertical bar or core of low expansion nickel steel alloy with a surrounding layer of molten copper in a carbon or graphite mould, causing the molten copper to solidify and weld-unite to the core. By this process (which is more specifically described in my application No. 539,245, filed Jan. 21, 1910), not only is a firm and permanent weld secured, but the article gives a wire which unites better with glass than does a copper-surfaced wire secured in other ways.

It is to be understood, of course, that the important temperature is that at which the glass sets from its plastic condition. This temperature varies somewhat according to the nature of the glass and in general is above 300° C.

In a modified form of the invention, I may use a wire comprising an annular sheath of nickel-iron alloy or other suitable high-melting ferrous alloy surrounding a central body of copper, but for most purposes the reverse arrangement is better. I may also use a leading-in wire having more than two layers of metal. For example, the wire may have a core of a high-melting ferrous alloy, a sheath of copper, and an exterior layer or coating of silver or gold incasing the compound core of the ferrous alloy and cop-

per. It is to be understood therefore that the term "core" as herein employed may refer not merely to a single core of a single metal or alloy, but may refer also to a composite core such as has just been described. The present invention includes a two-layer wire, the core being one layer and the sheath another; but either layer may be composite. It is also to be noted that a wire may be made with a high-melting alloy either coating or centrally coring a body of nickel-steel. The coefficient of expansion of such alloy is not likely, as a rule, to be as uniform as that of copper, for example; but it is only necessary that its expansion be sufficiently uniform to exert a substantial corrective effect on that of the nickel-steel and thus to force a more nearly uniform rate of expansion in the finished wire.

In referring to nickel-iron alloys, it is to be understood that this term covers all alloys containing nickel and iron which are suitable for present purposes by reason of their low expansion as compared with either nickel or iron alone and is used as synonymous with the term "nickel-steel."

By reason of the high compressive strains between glass and the like, and a metallic conductor sealed therein, which may be obtained according to the present invention, seals of this character are in many instances superior to those obtained by using leading-in wires of solid platinum. The tensile stresses between platinum and glass, due to the considerably higher rate of expansion and contraction of the platinum, may be entirely eliminated by the present invention, as has been clearly pointed out. On this account, it is now possible to substitute for platinum, which is so expensive and which is not wholly satisfactory, leading-in conductors having base metal or alloy surfaces; or having cores of base metals or alloys provided with external sheaths, of silver, gold or other non-platinum metal, much cheaper than platinum itself, the wire as a whole also being a better conductor than platinum and better suited to modern high capacity lamps.

While, as stated, I may use other combinations of metals, the best embodiment of the invention comprises a copper-coated nickel steel. The copper not only has the function of correcting the curve of expansion, but the greater further advantage of given a relatively high conductivity to the composite wire. Gold-surfaced and silver-surfaced wires are good conductors and less oxidizable; but the copper-surfaced wires on the whole I deem the best suited for my present purposes. Other low-expanding alloys and metals may be used in lieu of nickel steel, but the latter is best. The use of alloys of metals melting at low temperatures such as lead, tin, antimony, etc., is, of course, precluded by the heat necessary in sealing wire through glass.

While advantageously the expansion of the wire is as above pointed out, less than that of platinum or of the glass with which it is to be used, yet in another aspect the present invention may be said to include a method of reducing the expansion of highly conductive metals by uniting them with alloys of low expansion to produce a compounded reduced expansion; in the provision of a highly conductive wire of reduced expansion.

What I claim is:

1. A composite low expansion wire comprising a core of nickel steel and an external copper sheath welded thereto, said wire as a whole having less expansion than platinum.
2. A composite low expansion wire comprising a core of nickel steel and an external sheath of a metal of the copper class welded thereto, said wire as a whole having less expansion than platinum.
3. As a new article of manufacture, a copper surfaced wire having a rate of expansion as a whole below that of platinum.

4. As a new article of manufacture, a composite wire having a surface of base metal and having a rate of expansion as a whole below that of platinum.

5. As a new article of manufacture, a wire having a surface of metal of the copper class and a rate of expansion as a whole below that of platinum.

6. A 2-layer composite wire, one such layer being of low-expansion nickel steel and the other layer of high-expansion high-melting metal, the wire as a whole having an expansion less than that of platinum.

7. As a lamp wire, reinforced copper surface wire, said reinforcement consisting of an interior layer of low expansion nickel-iron alloy.

8. As a lamp wire, a composite wire composed of a layer of copper and another layer of low expansion nickel-steel in sufficient amount to reduce the total expansion sufficiently to secure a seal with lamp glass.

9. A leading-in wire comprising an outer sheath of high-melting, high-conductive material united to a core of nickel-steel having an average coefficient of expansion distinctly below that of the sheath, the core being under compression by the sheath at all temperatures to which the wire is subjected in lamp-making use.

*1,189,194, Eldred (Assigned to General Electric Co.),
June 27, 1916*

This invention relates to the production of a composite wire having a metallic core surrounded by a platinum sheath, for leading-in wires.

A bar of strong, ferrous metal, preferably a nickel-steel of such composition as to give the same rate of expansion as the glass, is coated with a film of silver, copper or gold. Copper is suitable. The rate of expansion of the filmed bar may be equivalent to that of the same thickness of the glass to be used. This filmed bar is now inserted into

a closely fitting sheath of platinum, and the temperature is raised to a point equal to or exceeding the melting point of the filming metal. The heat is preferably carried far enough to render this filming metal liquid or plastic.

I claim:

1. The process of producing clad metals which comprises producing a coating of metal of high expansion upon a metal of lower expansion, placing the coated core within a closely fitting shell of noble metal and heating to the fusing point of such coating metal to produce a metallic union between the core and shell.

*1,197,615, Eldred (Assigned to General Electric Co.),
Sept. 12, 1916*

This relates to leading-in wires for incandescent lamps, and a platinum substitute therefor.

The wire has a core of nickel-steel or other low expansion high-melting alloy or metal, and a sheath of platinum. The core may be made of a low expansion ferrous alloy of lower thermal expansion than the glass into which the wire is sealed.

A nickel-steel is preferred which, up to about 100° C. has an expansion of about 0.0000025, much less than that of platinum. A nickel-steel containing 38 per cent. of nickel answers the purpose very well. Since the rate of expansion is not constant, the core of nickel-steel is united with a regulating layer of copper, silver, gold, or platinum or their alloys. All these metals, with the exception of platinum, have a relatively high rate of expansion, which is not far from uniform at the temperatures here important. The union between the core and sheath must be absolute, and in the nature of a weld union.

Platinum is preferable to silver or copper as a sheath, because it forms a wetting union with molten or softened glass. The outer layer of platinum must be united to the

copper with a true metallic union, free from all flaws or defects. An intermediate layer of copper is also desirable.

It is possible to make this composite wire with a high temperature coefficient as low as 0.0000050, but it is found advisable to not go much below 0.0000070. With glass having a coefficient 0.0000068 and 0.0000072, gives particularly satisfactory results. The platinum sheath may sometimes be omitted, it being important that the wire have a lower coefficient of expansion than the glass. A nickel steel billet may be provided with a welded-on copper layer by the method described in U. S. Patents 853,716 or 539,245, and this layer turned down to the exact relative thickness required and inserted into a close fitting platinum tube or thimble. On now heating to the melting point of copper, the three layers become mechanically united. The billet may next be drawn or swaged to a wire and annealed.

I claim:

1. As a new material, a composite wire comprising a core of nickel steel, a layer of another metal of high expansion welded thereto, and an exterior sheath of platinum welded to said layer, said wire as a whole having a lower coefficient of expansion than platinum.

1,217,581, Eldred, Feb. 27, 1917

This relates to making clad metals.

If a body of steel is placed in a mould made of artificial graphite, which conducts heat freely, and a body of copper is placed next thereto, and the assemblage heated up to the fusing point of copper, and then locally cooled in a special manner while maintaining the heat, cohesively united compound bodies can be secured. Molten copper may be cast against the steel.

The local cooling is accomplished by cooling the base of the metals while maintaining the heat at the top; so that the line of solidification between the metals progresses upwards.

In a simple method of operation, a body of steel is placed in a container of synthetic graphite with a slab of copper next thereto and the mould placed in front of a furnace. The mould may now be pushed from one end of the floor of the furnace to the other and during its progress the copper is brought to a state of fusion. After the fusion is completed the mould is pushed on to a water-cooled floor at the end of the furnace while still exposed to the flames of the furnace, thereby securing the desired differential temperature.

I claim :

1. The process of making clad metals which comprises placing a body of a high melting iron-like metal in a mould, placing a body of an unlike, non-ferrous high melting metal of somewhat lower melting point in contact therewith, raising the temperature until the second-named metal melts and cooling the mould and contents from below upward by abstraction of heat from the bottom thereof while still supplying heat to the residue of the mould so that the topmost layer of molten metal shall be the last to solidify.

BRITISH PATENTS

CLASS 2.

21,621, Mito, 1892

A fusible alloy for connecting leading-in wires and platinum wires in making electric lamps consists of tin 95 parts and copper 5 parts; from $\frac{1}{2}$ to 1 per cent. of lead or zinc may be added. The alloy is stated to have about the same coefficient of expansion as glass and to be more fusible than glass. This alloy also secures the filament to the platinum wires.

11,695 of 1897

This corresponds to U. S. Patent 626,609 on page 121.

21,881 of 1899, Lake

Numerous experiments have heretofore been made with the object of substituting a less costly metal for the platinum which conveys the current to the filaments of incandescent lamps. The adaptability of alloys of steel and nickel for the above mentioned purpose has been particularly considered, but in applying such alloys in practice serious difficulties have been encountered so that it has been found necessary to modify the ordinary method of manufacturing these lamps. It is this particular method of manufacturing that forms the subject of the present application.

Nickel steel is far from being as refractory as platinum and the result is that it becomes brittle and oxidizes when introduced into the frame of a blow-lamp. Nickel steel

even when it has been annealed *in vacuo* evolves when heated to a high temperature a large amount of gas which remains interposed between the glass and the metal and this prevents the attainment of a tight steel or joint, which is necessary for maintaining the vacuum in the bulb of the lamp.

To obviate these facts I so arrange nickel steel wire that it does not come in contact with the frame. This is effected by inserting the wire in a glass tube which is heated to a temperature equal to, but not exceeding that required for softening the glass. The glass thus softened is caused to closely surround the metal by contraction or it may be applied to the metal by the aid of pincers or a like tool, or by other suitable means in such a manner as to form a tight joint. The surplus of the glass tube may, if desired, be then removed and the rest will be a combination of glass and metal which can be easily joined to the bulb. It is advantageous to employ as far as possible a very thin glass tube so that the softening of the glass may be rapidly effected. By this means the work is more quickly performed while at the same time the inconveniences arising from the heating of the metal are reduced to a minimum.

One arrangement which may be adapted for carrying out the method hereinbefore set forth, consists in blowing two small tubes to one end of a larger tube terminated by a bell-mouthed portion, which latter is subsequently welded to the bulb. A nickel steel wire is then inserted in each of the small tubes and the latter contracted around the metal wire in the manner hereinbefore explained. The carbon filament is next fired to the conducting nickel steel wires in the usual manner and finally the whole is joined to and enclosed in the bulb as is well known. The manufacture of the incandescent lamp is completed in the ordinary manner.

Instead of the above described arrangement the wire may be first imbedded in or surrounded by glass; on the other hand dipping it in molten glass or by putting glass

around it. The alloys of steel and nickel employed in the above combination of glass, steel and nickel, may be one of the following two groups:

1. The group containing from 29 to 30 per cent. of nickel.

2. The group containing from 43 to 48 per cent. of nickel.

Ordinarily, the alloys of the second group are employed in the manufacture of my improved lamps, such alloys being less oxidizable than those of the first group. The percentage of nickel is such as to obtain an alloy having the same coefficient of expansion as glass to which the bulb is made.

Hereinbefore mentioned percentages in nickel are suitable for alloys containing a very small proportion of manganese, chromium, and other metals frequently employed in metallurgy. But the coefficient of expansion of the alloys tends to increase with the percentage of these metals. Such increase may, however, be compensated by an increase in the percentage of the nickel for the first group and decrease for the second group. Generally speaking an alloy having the coefficient of expansion of a certain glass can be obtained by adding appropriate quantities of iron, nickel, chromium, manganese, and so forth, to the alloy of steel and nickel which contains about 36 per cent., and in which the expansion coefficient is approximately nil.

The invention therefore permits of the manufacture of incandescent lamps without the use of platinum which considerably reduces the cost of the lamp. Various trials have been made with the object of limiting the use of platinum in such lamps by employing conductors composed of 3 parts soldered together, end to end, in such a manner that only the portion traversing the glass is of platinum. This arrangement, however, increased the cost of manufacture while the low price of the above mentioned alloy permits of its employment for the whole conductor extending from the contact for the current to the filament.

Nevertheless, as this alloy may be easily soldered or brazed with other metals, it can also be used in the above described manner. Moreover, the invention is not limited, as in the case with platinum, to the employment of bulbs having a predetermined coefficient of expansion, such as that of platinum, since alloys can be provided having any desired coefficient of expansion.

24,918 of 1904, Hyde

(This corresponds to U. S. Patent No. 825,219.)

In the manufacture of incandescent electric lamps and analogous vessels requiring conductors to be sealed thereinto and a high vacuum to be retained therein, platinum has hitherto been the only conductor that could be satisfactorily sealed into the glass so as to make an air-tight joint.

Various attempts have been made to provide an economical substitute for platinum for this purpose. It is essential that such substitute shall have a coefficient of expansion so nearly that of glass into which it is to be sealed that when sealed into the glass of incandescent electric lamp bulbs, or analogous vessels an air-tight joint will be formed sufficient to maintain the required vacuum, and a cracking of the glass will not take place.

It is known, for example, that alloys of nickel with iron and especially those consisting of either 25 per cent. of nickel and 75 per cent. of iron or of 43 per cent. of nickel and 57 per cent. of iron have a coefficient of expansion, such that the conductors made of the said alloys can be sealed into glass without the glass cracking, or the conductors contracting, but the use of these alloys in place of platinum was open to serious objections. One objection was that unless special precautions which are expensive and troublesome, be taken, a film of oxide is formed on the surface of the nickel-iron alloy whilst it is being sealed into the glass, and this film prevents the close adhesion of the glass to the metallic surface of the conductor alloys, so that the air

permeates between the said metallic surface and the glass so that the necessary vacuum is not retained. Another objection to the use of such alloys is that frothing of the glass due to the evolution of gases occluded in the conductor, is liable further to impair the air-tight character of the joints.

For these reasons the use of conductors formed of aforesaid alloys has not been successful in practice in making joints which are required to be sufficiently tight to prevent leakage and retain a vacuum, the liability to leakage being too great to make conductors formed from the said alloys commercially efficient substitutes for conductors of platinum. Various means have been proposed with a view to overcome the objection due to oxidation; for example, it has been proposed to cover such conductor with a preliminary coating of glass applied *in vacuo* (see Carolan's Specification of Letters Patent No. 18,255, A. D., 1903), and it has been proposed to cover such conductors with a tube or sheath of non-oxidizable metal or alloy (see Thom's Specification of Letters Patent No. 908, A. D., 1890), but as far as I am aware, neither of such means has resulted in the production commercially, of a satisfactory substitute for platinum as a conductor.

My invention has for its object to overcome these difficulties and to produce an entirely satisfactory, and commercially available substitute for platinum as a conductor for the purposes aforesaid and I effect this by the following means.

I have discovered that hydrogen affects in a remarkable manner the behavior of certain metals and alloys (notably alloys of the platinum group), when they are in molten condition. I have found that hydrogen promotes the liquidity and mobility of the molten metal, or alloy, and that in the case of a molten alloy hydrogen enables a larger proportion of the more refractory metal to be used in the alloy than can be used at the same temperature without the mediation of hydrogen and I have found that, in coating a solid metal, or alloy with a molten metal or alloy, the hydrogen plays the part of a gaseous flux, its ac-

tion being such that the metal or alloy to be coated is as it were, wetted by the molten metal or alloy, producing an effect somewhat analogous to that brought about by ordinary fluxes in what is technically known as "tinning."

I have also found that hydrogen has the property of cleansing, or freeing from occluded gases, the aforesaid nickel in alloys, and the difficulty hereinbefore mentioned, due to the evolution of the occluded gases while sealing in the conductors is therefore likewise overcome by heating the said nickel-iron alloys in an atmosphere of hydrogen.

Applying these observations to the coating of nickel-iron alloys with a non-oxidizable metal or alloy, I have found that if I dip a wire or the like of nickel-iron alloy into an atmosphere of hydrogen the conductor produced possesses not only a coefficient of expansion, the same as, or approximately equal to, that of the glass into which it is to be sealed, but that the said conductor possesses all these physical qualities of surface which characterize platinum in its union with glass.

In this specification and also in the claims when I refer to a non-oxidizable metal or alloy I mean a metal or alloy which will not be oxidized under conditions pertaining to the sealing of the conductors into glass.

The non-oxidizable coating I prefer, is one consisting of an alloy of silver and platinum such that its melting point is sufficiently lower than that of the nickel-iron alloy, to allow of wires or the like of such nickel-iron being dipped in or passed through, a molten bath of the non-oxidizable alloy without the nickel-iron alloy being melted. The composition which I find most suitable is an alloy containing from 30 per cent. to 50 per cent. of platinum. I may coat the conductors of nickel-iron alloy by introducing them in suitable lengths in a molten bath of non-oxidizable coating metal or alloy contained in a crucible, or equivalent vessel, heated in any suitable manner which will keep the bath in the requisite molten condition, but I consider that the most practical way is to pass continuous lengths of conductor through the said molten bath, an atmosphere of

hydrogen being maintained in any case in the said crucible, or equivalent vessel, containing the molten bath during the coating operation. I may, for example, in coating a continuous length of conductor cause the wire, or the like, to pass from a reel through a suitable opening, or passage, and under the curved lower end of a guide of any suitable hard and highly refractory material such as porcelain or the like, the said guide being mounted so that it can be conveniently raised and lowered in the molten bath. The wire, or the like, after passing through the molten bath, is led through a suitable opening or passage, out of the crucible or vessel containing the bath, and may be wound on a receiving reel. The hydrogen can be admitted as required by a passage and an opening or openings in the upper part of the crucible or vessel, containing the molten bath or through passages made in the aforesaid refractory guide under sufficient pressure to maintain an atmosphere of hydrogen in the space above the molten bath and also if desired, in the passages, through which the wire, or the like, is laid, led and passed through the said crucible or equivalent vessel. The hydrogen can be withdrawn as desired by any suitable outlet opening and passage, or it may be burnt thereat provided that an atmosphere of hydrogen be maintained in the crucible, or analogous vessel containing the molten bath.

The thickness of coating applied to the conductors may be regulated by the rate of withdrawal of the conductor from the bath or by variation in the temperature of the bath, the higher the temperature the thinner being the coating. By the use of hydrogen as aforesaid during the coating process by means of the molten bath, I prevent oxidation of the nickel-iron alloy in the process of coating and I obtain a satisfactory adhesion of the non-oxidizable coating to the nickel-iron alloy and freedom from frothing and cracking of the glass in the sealing-in operation and an intimate adhesion between the coated conductor and the glass such as to render said coated conductor an economi-

cal and practical satisfactory substitute for platinum for the aforesaid purposes.

The coating operation by the molten bath in an atmosphere of hydrogen as aforesaid may be depended upon to cleanse the wire, or the like, from occluded gases or the wire, or the like, or, they can be previously treated to remove the said occluded gases (for example, by previously heating the said wire, or the like, in an atmosphere of hydrogen) and afterwards be passed through the molten coating bath in an atmosphere of hydrogen as aforesaid.

16,503 of 1907, Deutsche Gasgluhlicht Aktiengesellschaft

This invention relates to improvements in electric incandescent lamps and consists in an improved method of attaching tungsten filaments to the fused ends of the current leads.

At the present time the ends of the tungsten filaments used in electric lamps are attached in the current leads by fusing the ends of the leads which, when they solidify, hold the ends of the incandescent filaments firmly in place. This method can be carried out successfully when platinum wires are used as the current leads; but if nickel wires be used, frequent breakages will occur. This is caused by the formation of an alloy of a small portion of the nickel with the tungsten when the nickel ends are fused (by means of the electric arc). This alloy is itself readily fusible and causes a reduction in the sectional area of the filaments in the vicinity of the fused portion owing to the fusible alloy running down, and this causes the filaments to break readily at these weakened places. If copper be used for the current lead wire instead of nickel, another defect is caused by the filament breaking through and escaping from the surrounding fused globule before it has solidified.

The present invention relates to a means for obviating these inconveniences by using, as the current lead wire, a wire containing two metals; one of them being, for in-

stance, copper itself, or a metal (such as silver) which behaves like copper, and a second metal, for instance, nickel or a metal (such as iron) of analogous behavior.

It is important that one of the metals should readily form alloys with tungsten, while the other metal should not.

A convenient means consists in using wires composed of alloys of the aforesaid metals, though it is also sufficient for the two metals to be merely mechanically united, in the wires. For example, a wire can be used, composed of nickel with a coating of copper, or a copper wire coated with nickel.

15,342 of 1912, British Thomson-Houston Co.

Alloys of iron-chromium used for making leading-in wires to be sealed into vitreous articles, such as electric incandescent lamps, preferably contain from 20 to 30 per cent. of chromium, but the amount may range between 13 and 50 per cent. In making these alloys, chromium may be added to molten iron and under a slag, in an electric arc furnace, for instance, in which the iron has been freed from sulphur, phosphorus, carbon and other impurities. In working ingots into wire, longitudinal scratches should be avoided. The alloys have about the same expansion as glass, by which they are wetted when sealed, any oxide on the surface being so thin that it adheres both to the metal and the glass.

23,775 of 1912, British Thomson-Houston Co.

A composite wire for sealing into glass has a core, which may consist of an alloy of 54 parts of iron and 46 parts of nickel, sheathed, for instance, in an alloy of copper and cobalt. These parts may be united by a thin layer of an alloy of silver and copper.

~~See British Patent 13,413 of 1913 on page~~

See 13,413 of 1913 on page 228.

27,669 of 1913, Eldred

This corresponds to U S. Patent 1,140,136 on page 128.

13,207 of 1915, British Thomson-Houston Co., Ltd.

This invention relates to an improved alloy which has been found particularly suitable for use in the manufacture of lead wires for electric lamps, and consists of an alloy of nickel, cobalt and manganese.

The proportions in which the three metals are alloyed may be as follows:

Cobalt	20 to 30 parts
Nickel	80 to 70 parts
Manganese	A few parts

In accordance with this invention the alloy can be prepared as follows:

One part by weight of cobalt and three parts by weight of nickel are melted together in an aluminium crucible, the metal being preferably protected by an atmosphere of hydrogen, $1\frac{1}{2}$ to 2 per cent. of manganese is added to the melt and after it has become quiescent, it is cooled to about 1250° C. and then chilled in water.

In preparing the alloy, care should be taken to avoid aluminium, lime and other basic impurities, and the materials should also be free from sulphur, phosphorus, silicon and carbon. These impurities tend to make the alloy brittle, but traces of iron do not appear to have a detrimental effect.

The alloy is exceedingly ductile and malleable and may readily be drawn into wire. It is almost pure white in luster, being a blend between the yellowish tint of nickel and the bluish tint of cobalt. It has an exceptionally low heat conductivity and does not absorb gas and is therefore particularly suitable as a supporting or current lead wire for electric incandescent lamps. The melting point

of the alloy is above 1500° C. and when used as a current lead wire in an electric lamp the wire may become red hot without the envelope of the lamp being discolored. By the use of current lead wires consisting of the new alloy the efficiency of low voltage miniature lamps is very much improved because the heat loss by conduction from the filament is reduced.

104,758, General Electric Company, May 9, 1917

A conductor adapted to be sealed into glass consists of a thin metal sleeve, a metal core, both serving to convey current, and a thin intermediate layer of refractory material, such as carbon, clay, plaster of paris, powdered cast iron, steel, or other metal not capable of cementing the sleeve and core, on an oxide such as silica, manganese dioxide, etc. The sleeve adheres to the surrounding glass and not to the core, during expansion and contraction. The sleeve and core may have different melting points, and are preferably of metals easily soldered or welded, a brass tube may, for instance, be used with a copper core, or a copper tube with a brass core thinly coppered. Platinum, nickel-iron, or other metal having the same coefficient as glass may be used for the sleeve. When the conductor is sealed into glass, leakage through the refractory layer may be prevented by fusing the end of the conductor or by soldering it. Or, a piece of the composite metal may be welded to solid wires, the weld being preferably within the seal.

PREFACE TO CLASS 3

In this class are some of the various alloys considered suitable for electric resistance purposes and for ignition points for spark plugs and magnetos. These particular objects are not stated in some of these patents, but it will be apparent that any metal or alloy which meets the requisite tests of non-volatility, non-oxidation, infusibility and non-corrosion will be suitable for electrical resistances or for use as ignition points.

This class shows a large number of patents most of which use chromium alloys. Nearly all of these patents were issued after 1900.

The majority of the alloys of this class contain nickel, chromium, tungsten, and the like. However, a series of patents all granted before 1900, show the use of nickel and chromium for non-oxidizing alloys so that this basic idea is open free to public use. In particular, U. S. Patent No. 573,615 shows the advantages of chromium for making a non-oxidizing alloy. Attention is called to German Patent No. 281,784 on page 271, which would seem to indicate that the alloys of Class I would be suitable for the purposes of this class, if some platinum is added.

U. S. PATENTS

CLASS 3-A

811,859, Marsh, Feb. 6, 1906

My object is to provide as an improved electric resistance material, a metal which has the property of being particularly low in electric conductivity, has a melting point exceeding that of pure copper and may be drawn or otherwise shaped to form particularly durable, efficient and desirable strips, strands, or filaments suitable for use in the various connections where electric resistances are desirable.

I have discovered that the metals of what is termed the chromium group, particularly when mixed with nickel, form an alloy having the properties of being very low in electric conductivity, very infusible, non-oxidizable to a very high degree, tough and sufficiently ductile to permit drawing or shaping it into wire or strip form to render it convenient for use as an electric resistance element. The chromium group herein referred to, as defined, for example, in Watt's Dictionary of Chemistry, consists of the metallic elements of group No. VI (indicated by the even number series) according to what is generally designated as Mendeleeff's table. These metals are chromium, tungsten, molybdenum, and uranium. Any one of these metals is suitable for my purpose, though for various reasons I prefer to employ chromium. Uranium at the present time is so rare and expensive as to render its general use for my purpose commercially prohibitive and as the above metals possess characteristics in common which adapt them to my purpose, any one of them may be employed, though when

alloyed with nickel or cobalt, for example, the proportions may vary to produce the best electric resistance, taking into consideration necessary toughness and degree of ductility desirable for the particular purpose in hand. I have found, for example, that an alloy consisting of 90 per cent. of nickel and 10 per cent. commercially of pure chromium may be drawn into a fine wire and annealed, producing a tough metal having a melting point exceeding that of pure copper and with an electric resistance approximating fifty times that of pure copper. Its temperature coefficient is particularly low, it does not become crystalline and brittle under heating and cooling, but resists oxidation to a remarkable degree under very high temperature, and likewise keeps a polish under all atmospheric conditions even where corrosion fumes are present.

Any metal of the chromium group possesses desirable qualities for electric resistance material whether employed alone or alloyed with nickel or cobalt. At the present time I am of opinion that the most practical and desirable electric resistance material may be formed of an alloy of nickel and chromium in suitable proportion drawn into strips, strands, or filaments and annealed. In its broadest sense, however, my invention is not to be limited to an alloy of the last named metals. In practice I prefer mainly for commercial reasons to form an alloy of preferably less than 25 per cent. chromium and more than 75 per cent. of nickel. Variations in the relative proportions of the metals produce more or less variations in strength, durability, and resistivity of the alloy. It may be stated, for example, that a metal alloy consisting of 15 per cent. of chromium and 85 per cent. of nickel drawn into wire 0.016 of an inch in diameter has a resistance approximating 2.3 ohms per foot.

As stated before, either nickel or cobalt is suitable for my purpose when alloyed with a metal of the chromium group in a proportion of more than 50 per cent. of nickel or cobalt, or both, and less than 50 per cent. of chromium or the like. Nickel and cobalt readily alloy with metals

of the chromium group and resist oxidation to a high degree. Iron, on the other hand, is readily oxidizable, and will not answer my purpose when alloyed with a metal of the chromium group.

I claim:

1. An electric resistance element composed of a metal alloy consisting of one of the metals of the chromium group, in which the proportion of less than 50 per cent. of the elements, and more than 50 per cent. of metal having the properties of nickel and cobalt.

2. An electric resistance element comprising a strip or strand or filament formed of an alloy of nickel and one of the metals of the chromium group.

824,103, Driver, June 26, 1906

My invention consists of a new and useful improvement in alloys or compounds of copper, nickel, and manganese which are designed primarily for use as electrical resistance to take the place of materials heretofore used for that purpose, especially German silver which has for many years been regarded as the standard material for the purpose, but which possesses many disadvantages that are eliminated by using the alloy of my invention.

The object is to produce an alloy that shall not only have a high and practically constant resistance, but one that is permanent and stable in its physical and electrical properties.

The particular disadvantage of German silver is that after repeated heatings and coolings in service it crystallizes and breaks. This is due to the presence of zinc and is not an infrequent occurrence in any alloy of which zinc forms a considerable part, and for this reason I have omitted zinc in my new alloy. "Eighteen per cent. German silver," the grade most frequently used, is composed 18 to 20 parts nickel, 10 to 25 parts zinc, and 55 to 72 parts copper. In my improved alloy I have about the same pro-

portion of copper and of nickel, but have replaced the zinc with about 5 parts of manganese. This makes an alloy consisting of about 75 parts copper, 20 parts nickel, and 5 parts manganese. Nickel and manganese each have the effect of increasing the resistance of the alloy, the manganese, however, to a much greater extent than the nickel; but manganese has a tendency to make the alloy unstable, and therefore a considerable amount of nickel—10 per cent. or more—is used for the purpose of “fixing” the electrical qualities of the resultant alloy.

Alloys have been heretofore suggested consisting of copper and nickel with manganese; but the manganese entering into the composition was usually in the form of ferromanganese, and the result was the production of an alloy which would rust and rapidly deteriorate upon exposure even to the atmosphere. By the use of pure manganese iron does not enter into my composition, and therefore the possibility and probability of deterioration from rust is eliminated. Moreover, such copper-nickel-manganese alloys as have been attempted were found to be brittle or otherwise unworkable in addition to their want of stability and liability to rust. This brittleness is possibly due to the proportions used.

In the manufacture of my alloy I employ the ordinary method of making alloys—that is, take the three ingredients in the proportions, by weight, indicated, and place them in a crucible and then apply heat to fuse the mixture, or they may be melted separately and then mixed—any ordinary method of making alloys. In this manufacture great care must be taken lest an appreciable amount of iron, silicon, carbon, or other foreign substances be present in the finished article; but if these substances are present in small quantities only they will have very little influence on the value of the commercial alloy.

The proportions named above can be varied considerably without materially changing the effectiveness of the alloy; but for the reasons stated I prefer the ingredients to be of practically the percentage specified.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is the following:

1. A new composition of matter containing copper and nickel with from 5 per cent. to 10 per cent. of manganese and being essentially free from iron or other foreign substances.

2. A new composition of matter consisting of an alloy containing copper and manganese with 20 per cent. of nickel.

824,618, Birmingham, June 26, 1906

The object of this invention is to provide an alloy which will be fusible only at a very high temperature and one which may be used as a substitute for platinum, especially as employed in connection with electrical appliances.

The alloy is composed of the following ingredients in about the proportions specified—to wit, silver, $16\frac{1}{2}$ ounces; nickel, $4\frac{1}{5}$ pounds; bismuth, $\frac{1}{2}$ ounce, and gold 53 pennyweights. These proportions, which are according to Troy measure, may be varied without materially altering the properties of the compound; but I have found those stated to be productive of best results.

An alloy composed of the parts specified may be used wherever platinum is now ordinarily required—for instance, as the leading-in wires for incandescent lamps, contact-points for electric vibrators, and, in fact, in all classes of electrical appliances where high resistance is required. The compound is also highly advantageous in connection with telephone transmitters, being highly ductive and far more durable than platinum.

I claim as my invention:

1. An alloy composed of silver, nickel, bismuth and gold.

2. An alloy composed of silver $16\frac{1}{2}$ ounces; nickel, $4\frac{1}{5}$ pounds; bismuth, $\frac{1}{2}$ ounce, and gold, 53 pennyweights.

My object is to provide, as an improved electric resistance material, a metal which has the property of being particularly low in electric conductivity, has a melting point exceeding that of pure copper, and may be drawn or otherwise shaped to form particularly durable, efficient, and desirable strips, strands, or filaments suitable for use in the various connections where electric resistances are desirable.

I have discovered that when comparatively small proportions of certain metals having refractory oxides are added to nickel or cobalt, or to either of these metals alloyed with a metal of the chromium group, as defined in Letters Patent No. 811,859, granted to me February 6, 1906, the durability under high temperatures of the alloy so produced is augmented. For example, an alloy of nickel and chromium containing about 10 per cent. chromium, when heated, in the atmosphere, to a white heat, becomes coated with a black oxide; and that when about 4 per cent. of aluminium is added to this alloy, the scale so formed is thinner, tougher and more adherent and affords a better protection against further or destructive oxidation than is afforded by the black oxide of the first mentioned or simple alloy. A wire of the alloy containing aluminium has been heated to incandescence at a temperature so high as to actually melt the metal or core within the film or shell of oxides formed under lower temperature upon the wire, which effectively protected the core against further or destructive oxidation, by reason of its tough or coherent properties, which maintain it intact.

While such metals as aluminium, tin, silicon, and manganese increase the electrical resistance of nickel, or nickel alloyed with a metal of the chromium group, their principal advantage consists in the deoxidizing action they exert on the metal or alloy to which they are added and the protecting property of the oxide film formed from the alloy; though nickel containing about 3 per cent. alu-

minium has a resistance of about 0.53 ohms per foot of wire of 0.40 mm. diameter, whereas the nickel from which the alloy was made has a resistance of only about 0.26 ohms per foot of wire of like diameter, so that the addition of the 3 per cent. aluminium doubles the resistance.

A very good alloy for a resistance element having the oxidizing property set forth, and one which may be rolled or drawn into wire, is composed of about 88 per cent. nickel, about 8 per cent. chromium and about 4 per cent. aluminium. This alloy drawn into wire 0.40 mm. in diameter has a resistance of about 2.2 ohms per foot, which is about fifty times that of pure copper. Moreover, the chromium increases the melting point of the metal.

Though, so far as I am at present aware, aluminium is the most desirable metal for my purpose, as an addition to nickel or its alloys, my invention is intended to include any metal more electropositive than nickel and having a refractory oxide with a melting point of 1200° C., or higher.

I am aware that aluminium, manganese, silicon and other metals have hitherto been added to nickel and other metals to produce sound castings, but it was hitherto unknown that the resultant alloys would produce electric resistance elements having the surface oxidizing property with the protecting advantage hereinbefore explained.

Either nickel, or cobalt which has similar properties, is suitable for my purpose when alloyed with aluminium in, substantially, the proportions specified, or with any metal herein referred to as the equivalent of aluminium, with or without the member of the chromium group as an element of the alloy. Where I mention in the appended claims a metal having the properties of nickel or cobalt, I wish to designate only the metals nickel and cobalt, which have properties that are the same for my purpose, but which cannot both be classed under any single term of which I am aware.

What I claim as new, and desire to secure by Letters Patent is:

1. An electric resistance element composed of an alloy consisting of metal having the properties of nickel and cobalt, and a relatively small proportion of another metal more electropositive than nickel and having a refractory oxide with a minimum melting point of about 1200° C.

2. An electric resistance element composed of an alloy consisting of metal having the properties of nickel and cobalt, and a relatively small proportion of aluminium.

See U. S. Patent 887,173 on page .

See U. S. Patent 901,428 on page .

903,861, Hughes, Nov. 17, 1908

This invention relates to electric arc lamps of the hot wire type, that is wherein the feed is effected through the medium of a mechanism including as an element a thermo-expansive wire.

The object of the invention is to provide an alloy for use in the making of the wire, which alloy will have a high coefficient of expansion, will have a sufficiently high tensile strength to suit the working conditions to which it is subjected, and the efficiency of which will not be impaired when subjected to high temperatures.

The alloy of which the thermo-expansive wire is formed, consists of copper, 57½ per cent.; nickel, 42 per cent., and lead ½ of 1 per cent.

What is claimed is:

1. An arc lamp including a thermo-expansive member comprising nickel, copper and lead.

2. An arc lamp including a thermo-expansive member consisting of an alloy comprising the elements and proportions substantially as follows: 57½ per cent. copper; 42 per cent. nickel, and ½ of 1 per cent. lead.

923,152, *Dempster* (Assigned to General Electric Co.),
June 1, 1909

My invention comprises what I may term an alloy of silicon and tellurium. This alloy may be used for a variety of purposes, but is especially adapted for use as a resistance material in connection with lightning arrester resistances, heating units, and so forth. Such an alloy of silicon and tellurium possesses a higher specific resistance than commercial silicon now in use as resistance material.

The tellurium can be alloyed with the silicon in a variety of proportions, according to the properties desired in the alloy. Alloys useful as resistance material, in general, may contain from 1 to 15 per cent. of tellurium. I prefer to add about 5 per cent. of tellurium in making the high-resistance alloy, as this amount of tellurium increases the resistance of the silicon from three to five times, without making it brittle or introducing any other undesirable physical changes in the cast material.

I prefer to place with the tellurium in the bottom of the crucible a layer of a powdered carbonate which is decomposable at the melting temperature of silicon, about 1430° C. as, for example, calcium carbonate, CaCO_3 . When the mass is heated the calcium carbonate is decomposed with the formation of calcium oxide and carbon dioxide. The carbon dioxide, when rising from the melting silicon, appears to act as a decarburizer, reacting with the carbon usually associated with the silicon to form carbon monoxide. The calcium oxide, because of its low specific gravity, rises to the surface, where it comes into contact with the silica, which has been formed on the surface of the melted silicon by oxidation, and combines with it either entirely or in part, with the formation of a slag of calcium silicate which floats upon the melted alloy and protects both the silicon and tellurium from oxidation. This method of alloying produces a superior product, free from carbon and oxides.

If desired, the silicon and tellurium can be alloyed by melting them together in an ordinary crucible; the tellurium being placed in the bottom of the crucible and covered with broken pieces of silicon. A simple melting is sufficient to dissolve and distribute the tellurium in the melted silicon, which is then cast into the desired form.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An alloy containing silicon and tellurium.
2. An alloy consisting of silicon alloyed with 1 to 15 per cent. of tellurium.

926,980, *Dempster (Assigned to General Electric Co.)*,
July 6, 1909

This invention relates to alloys of various metals and has for its object the production of alloys by a process which is simple and at the same time lends itself to the formation of an alloy in which the composition is accurately and definitely known.

In my previous patent No. 901,428, I have described and claimed a resistance conductor which has valuable properties adapting it to a variety of uses. This alloy is heat-refractory to an extraordinary degree. It does not easily oxidize when subjected to a prolonged red heat in the atmosphere. It is acid-proof and has high electrical resistivity adapting it for electric heating and rheostat work. The slight oxidation which the wire undergoes from prolonged red heat goes on slowly and the oxide is coherent and does not materially change its conductivity. The composition which I have found very successful contains approximately:

62 parts nickel	(by weight)
20 parts iron	"
13 parts chromium	"
5 parts manganese	"

In the melting of this alloy it was found that carbon must be excluded from the mixture since otherwise the alloy became hard and brittle. It was found, moreover, that nickel is high in carbon and that it is therefore necessary to purify the nickel in making up the alloy. Graphite crucibles cannot be used because of the fact that the metals of the alloy will take up carbon. Clay-lined crucibles serve the purpose excepting for the fact that the manganese attacks the clay and exposes the graphite. The following process has been found to operate satisfactorily. In the bottom of a clay-lined graphite crucible is placed an oxide to serve as a decarbonizer. This oxide may be hematite (Fe_2O_3). It is found that about 8 pounds of this oxide is necessary for 100 pounds of alloy. Nickel is then charged into the crucible with a small quantity of silica and cryolite as flux, and when the nickel is melted the heat is run up to promote a vigorous reaction between the oxide and the carbon. This reaction is shown by the gas bubbles igniting above the slag and burning with a blue flame. When the metal quiets down, the carbon being eliminated, the iron is added and after this is melted the chromium is added. While the mixture is in a molten condition, care being taken not to excessively heat the metal and burn the lining, the manganese is added in suitable quantities. The mixture is then quickly poured before the manganese attacks the clay lining.

By this process I am able to practically eliminate the carbon from the mixture and obtain an accurately proportioned alloy in a simple manner.

While I have described my invention in connection with specific metals mixed in certain portions as well as steps of the process taken in a certain way, it should be understood that I do not limit my invention thereto except in so far as it is limited by the scope of the claims annexed hereto.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The process of producing alloys which consists in melting a quantity of nickel with a decarbonizing agent in a clay-lined crucible to reduce the carbon, adding iron and chromium in suitable proportions, then adding manganese and pouring the mixture before the manganese attacks the clay lining.

937,284, *Craft and Harris (Assigned to Western Electric Company)*, Oct. 19, 1909

Our invention relates to an alloy for use in connection with electrical apparatus, and more particularly to an alloy which may be employed as a substitute for platinum in electrical contacts.

The object of our invention is to provide an alloy which is cheaper than platinum, and which nevertheless possesses the properties which render that metal valuable for use in connection with electrical appliances.

Our invention consists of an alloy of gold, silver and some metal, such as platinum, capable of imparting hardness to the alloy.

The silver is introduced in quantities sufficient to materially lessen the cost, without destroying the non-tarnishing property of pure gold, which latter metal constitutes the larger portion of the alloy. This mixture of gold and silver is so alloyed with sufficient quantities of the hardening metal, preferably platinum, to produce the degree of hardness required in material for electrical contacts. The alloy is composed of the above named constituents in about the following proportions: gold, $67\frac{1}{2}$ to 70 per cent.; silver, 25 per cent.; platinum, 5 to $7\frac{1}{2}$ per cent.

The working requirements for contacts of electrical apparatus make it essential to restrict the component metals of the alloy of our invention rather closely to the proportions given above.

In order to make the alloy as cheap as possible, without detracting from the proper working qualities, we do not use any more gold than is necessary to overcome the tarnishing tendency of silver. We have found that we can safely use, as a maximum, 30 per cent. of silver, and still produce an alloy which will not corrode in service, and that we can use, as a minimum, 25 per cent. of silver without unduly increasing the cost of the alloy. As to the proportion of platinum, we have found that the physical properties of the alloy begin to be injured seriously if platinum is present to a much greater extent than $7\frac{1}{2}$ per cent., while not sufficient hardness and a low melting point is obtained if much less than 5 per cent. of platinum is employed. Moreover, if a greater amount of platinum than about $7\frac{1}{2}$ per cent. is present, the cost is unnecessarily increased, and the alloy becomes less homogeneous.

The process of manufacturing this alloy does not differ materially from the standard practice in the manufacture of alloys of precious metals. The proper proportions of the three constituents are weighed out and placed in a crucible, and there subjected to a heat sufficient to melt the material. Considerable care, however, must be exercised in order to insure the uniform alloying and mixing of the constituents, and it is preferable to remelt the alloy one or more times after the first melting in order to insure the perfect mixing of the constituent metals. This, however, is standard practice, and further description thereof is unnecessary. The alloy of gold, silver and platinum in the proportions above mentioned has been found to possess practically all the characteristics peculiar to platinum, and furthermore, the advantage of being considerably cheaper than platinum, and somewhat harder than that metal.

We claim :

1. An alloy composed of $67\frac{1}{2}$ to 70 per cent. gold ; 25 per cent. silver and from 5 to $7\frac{1}{2}$ per cent. of a hardening metal.

2. An alloy composed of gold, silver and platinum, in approximately the following proportions: Gold, $67\frac{1}{2}$ to 70 per cent.; silver, 25 per cent.; platinum, 5 to $7\frac{1}{2}$ per cent.

937,285, *Craft and Harris (Assigned to Western Electric Company)*, Oct. 19, 1909

Our invention relates to an alloy for use in connection with electrical apparatus, and more particularly to an alloy which may be employed as a substitute for platinum in electrical contacts.

The object of our invention is to provide an alloy which is cheaper than platinum, and which nevertheless possesses the properties which render that metal valuable for use in connection with electrical appliances.

Our invention consists of an alloy of gold, silver and nickel. The silver is introduced in quantities sufficient to materially lessen the cost, without destroying the non-tarnishing property of pure gold, which latter metal constitutes the larger portion of the alloy. This mixture of gold and silver is so alloyed with sufficient quantities of nickel to produce the degree of hardness required in material for electrical contacts.

The alloy is composed of the above named constituents in about the following proportions: Gold, $67\frac{1}{2}$ per cent. to 70 per cent.; silver, 25 per cent.; nickel, 5 per cent. to $7\frac{1}{2}$ per cent.

The working requirements for contacts of electrical apparatus make it essential to restrict the component metals of the alloy of our invention rather closely to the proportions given above.

In order to make the alloy as cheap as possible, without detracting from the proper working qualities, we do not use any more gold than is necessary to overcome the tarnishing tendency of silver. We have found that we can safely use, as a maximum, 30 per cent. of silver, and still produce an alloy which will not corrode in service, and

that we can use, as a minimum, 25 per cent. of silver without unduly increasing the cost of the alloy.

As to the proportion of nickel, we have found that the physical properties of the alloy begin to be injured seriously if nickel is present to a much greater extent than $7\frac{1}{2}$ per cent., while not sufficient hardness and a low melting point is obtained if much less than 5 per cent. of nickel is employed. Moreover, if a greater amount of nickel than about $7\frac{1}{2}$ per cent. is present, there is a slight increase in the tendency of the alloy to corrode.

The process of manufacturing this alloy does not differ materially from the standard practice in the manufacture of alloys of precious metals. The proper proportions of the three constituents are weighed out and placed in a crucible, and there subjected to a heat sufficient to melt the material. If an electric furnace is employed, it is preferable to melt the nickel in a graphite crucible which has been flashed with magnesia or lime in order to prevent the carbon of the crucible from uniting with the nickel. After the nickel is melted the gold and silver are added and the heat thereupon lowered to the melting point of the alloy, namely, to approximately 1300° C.; or any other suitable method of alloying the metals may be employed. It is preferable to remelt the alloy one or more times after the first melting in order to insure the perfect mixing of the constituent metals. This, however, is standard practice, and further description thereof is unnecessary. The alloy of gold, silver and nickel in the proportions above mentioned has been found to possess practically all the characteristics peculiar to platinum, and furthermore, the advantage of being considerably cheaper than platinum, and somewhat harder than that metal.

We claim:

An alloy composed of gold, silver and nickel, in approximately the following proportions: Gold, $67\frac{1}{2}$ to 70 per cent.; silver, 25 per cent.; nickel, 5 to $7\frac{1}{2}$ per cent.

This invention relates to alloys intended for electrical conductors.

The object of the invention is to provide a conductor having a very high melting-point as well as a very high electrical resistance, and that shall also be to a large extent non-corroding. It is quite desirable in a resistance-alloy for some lines of work to have a very high melting-point, as the material is often subjected to excessive temperatures.

I have discovered that alloys of nickel and manganese, especially where the nickel predominates, present the three qualities mentioned. Pure manganese is brittle and easily broken. An alloy consisting of nickel and manganese, in which the nickel predominates, is ductile and malleable, and is suitable for making into sheets or wires. Pure nickel has a comparatively low resistance, only about 12 microhms per cubic centimeter. A mixture of 95 per cent. of nickel with 5 per cent. of manganese gives a resistance of about 25 microhms per cubic centimeter, or twice that of pure nickel. Eighty per cent. nickel with 20 per cent. manganese gives a resistance of about 70 microhms; while 70 per cent. nickel and 30 per cent. manganese has a resistance of about 100 microhms. The melting-point of these alloys is estimated to be in the neighborhood of 2500° F. These alloys all have the advantage of not corroding readily on exposure to the air. They have the further advantage of electric stability, differing in this respect from alloys of copper and manganese alone; copper-manganese alloys seem to require one or more additional ingredients, whereas these nickel-manganese alloys (where there is a high percentage of nickel) seem to require no third ingredient to "fix" their electrical properties.

The percentages given are merely for the sake of illustration, since I do not confine myself to any particular percentage, except that for mechanical reasons it is generally preferable that the nickel should be 50 per cent. or more of the mixture, in fact about 70 per cent., since where there

is more than 30 per cent. of manganese, there is strong tendency to brittleness, which is objectionable if the alloy has to be worked into wire or sheet form. Moreover, while I have spoken of a composition consisting of manganese and nickel, of course the presence of any other ingredient or ingredients would not be a departure from the spirit of my invention so long as such addition does not to a material extent interfere with or lessen the three desired qualities.

While as just said it is generally preferable that the nickel should preponderate over the manganese, yet an alloy in which the manganese preponderates will also give high resistance and high melting-point, and will be practically non-corrosive, but there should generally be not less than 50 per cent. of nickel and not less than 5 per cent. of manganese.

Having thus described my invention, I claim :

1. An alloy containing manganese, with 60 per cent. or more of nickel.
2. An electrical resistance element composed essentially of nickel and manganese.

953,412, *Dempster (Assigned to General Electric Co.)*,
March 29, 1910

To make a high resistance metal a very large percentage of iron is used in combination with tellurium, silicon, and manganese. The tellurium and silicon are first formed into an alloy, as shown in U. S. Patent 923,152. Molten iron which has been decarbonized and purified, is poured into a ladle containing pieces of this alloy, or the alloy can be added to a bath of molten iron. This is cast into ingots and may be made in sheets or wire. A suitable alloy is made of 91.6 per cent. iron; 2 per cent. tellurium; 6 per cent. silicon; 0.5 per cent. manganese.

I claim :

1. An alloy containing iron, tellurium and silicon.

961,217, *Driver, June 14, 1910*

This invention relates to alloys intended primarily for electrical resistances, and is based upon the discovery that a substantial amount of aluminium added to alloys produces a marked effort upon their electrical resistances, especially in alloys composed mainly of copper or of iron.

Quantities of aluminium varying from about 1 to 9 per cent. can be added to alloys of copper and nickel, of copper and manganese, and of copper and nickel and manganese and (within limits explained below) to alloys of iron and nickel with marked benefit. Alloys of copper and nickel have their maximum resistance with 42 per cent. of nickel. An addition of 2 to 8 per cent. of aluminium to copper-nickel alloys increases their resistance, but where the percentage of nickel is high, the amount of aluminium must be low, to avoid brittleness.

In alloys of copper and aluminium, the amount of aluminium should be about 5 per cent.

An alloy containing 30 per cent. of nickel, 65 per cent. of iron, and 5 per cent. of aluminium gives good results.

I claim:

1. An electrical resistance element, consisting of an alloy containing a substantial amount of aluminium with at least two other ingredients.

981,542, *Driver, Jan. 10, 1911*

My invention is a new alloy or a series of alloys, intended primarily for use as resistance-material in electrical work.

The object of the invention is to produce alloys having high, and even abnormally high, specific resistances; alloys which are also reliable and permanent in their physical properties (*i. e.*, ductile and not liable to deteriorate from rust upon exposure to atmosphere), and which are likewise reliable in their electric behavior. Although ductility is an exceedingly desirable property, yet where the alloy is to be employed in cases where it is not necessary to

work it, or in other forms than drawn wire, some ductility may be sacrificed in obtaining increased specific resistance.

The specific resistance of ordinary copper is about $1\frac{2}{3}$ michroms per cubic centimeter. Taking this resistance of copper as the unit, the resistance of the alloy "mangamin" as compared with that of copper is about 24 (or about 40 michroms per cubic centimeter); of 18 per cent. German silver about 18; of 30 per cent. German silver about 28; of "advance" or "constantan" about 28. And these are the highest figures of any satisfactory material now known which will not rust. There is a demand for alloys having much higher specific resistances—resistances of about 80 or more michroms per cubic centimeter or fifty or more times that of copper. This amount of resistance is what I mean by "abnormally high" specific resistances. While it is true that a class of alloys has been produced with a very high specific resistance (about 83 microhms per cubic centimeter), yet it has proved unsatisfactory on account of certain inherent defects. The alloys of this class contain iron and nickel; but such alloys inevitably deteriorate more or less rapidly from rust, on account of the large quantity of iron.

It is well known that the addition of manganese to copper tends to raise the specific resistance; but if we increase the amount of manganese sufficiently to attain an abnormally high or even a comparatively high, specific resistance, the alloy becomes unreliable and unstable in its electric behavior. So that past experience has served to shut the door to manganese as a means for producing a commercially satisfactory alloy of very high resistance. Nickel is also known to increase the resistance of the alloys into which it enters, but to a degree inferior to manganese. So that the addition of nickel will not produce the abnormally high specific resistance. Nickel and manganese have been used conjointly with copper. But the nickel has been taken only in very small percentages.

I have discovered that nickel has the property, when entering into an alloy of copper and manganese, of "fix-

ing the electrical behavior of the alloy; when the percentage of manganese is increased, it is generally desirable to increase the amount of nickel; this increase, however, is not essential. An increase of nickel tends to harden the resultant alloy, which is sometimes an objection. When to copper is added a large percentage (10 per cent. or over) of manganese and also a large percentage (10 per cent. or over) of nickel, there is obtained a homogeneous alloy that is ductile and workable, one that does not rust, and above all that has a very high specific resistance and is reliable and constant in its electrical behavior. By this departure from the teachings of past experience, I obtain to a higher degree than heretofore deemed possible all the benefit of manganese, but without the disadvantage, heretofore supposed to be inseparable from the presence of a high percentage of manganese.

The following formulas give the proportions of the three ingredients and the specific resistance of each composition, stated in michroms per cubic centimeter:

Copper	Manganese	Nickel	Specific Resistance
60	10	30	65
45	10	45	68
75	15	10	53
65	15	20	61
70	20	10	68
60	20	20	75
50	20	30	88
40	20	40	98
65	25	10	85
60	25	15	93
55	25	20	95
55	30	15	113
50	30	20	123
50	35	15	124
40	40	20	150

The proportions above indicated may, of course, be varied considerably without losing the effectiveness of the alloys or departing from the spirit of my invention, the result of such variations being to raise or lower the specific resistance, which in any case will be high. The spirit of my invention consists in using both manganese and nickel in proportions much larger than heretofore employed. My experiments, as illustrated by the formulas given, indicate that there must be 10 per cent or over of nickel, conjointly with 10 per cent. or over of manganese.

Having thus described my invention, I claim :

1. A ductile and stable electrical conductor of non-rusting material, having an abnormally high specific resistance, substantially as described.
2. An electrical resistance-element containing copper, with manganese and nickel, the two latter being present in large amounts, namely, at least 10 per cent. of each substantially as described.

993,042, Driver, May 23, 1911

This invention relates to alloys intended especially for electrical resistances.

The object of the invention is to produce workable alloys which will have high electrical resistances, with high melting-points, and that will not deteriorate to any noticeable extent upon exposure to the atmosphere.

Various alloys have been known and used for electrical resistance, having more or less high electrical resistance, but as a rule the melting-points of these alloys are comparatively low, and many of them are not stable in their electrical properties and besides are liable to deteriorate from rust, etc.

Nickel is malleable, has a high melting-point, is practically non-corrosive, and is reasonably cheap. The alloys composed of nickel and manganese alone (disregarding

any other substances that may be present as impurities) have quite a high electrical resistance, but one purpose of this invention is to increase the resistance of such alloys still further. In general also, by increasing the percentage of manganese in the alloy, the electrical resistance is increased; but there is a limit to the percentage of manganese that may be employed, because too much manganese will render the alloy unworkable. On the other hand, any increase of the percentage of nickel is the same as decreasing the percentage of manganese, and the resistance is thereby reduced.

Although copper, for instance, has a far lower specific electrical resistance than nickel and manganese, yet if a small proportion of copper (or, so far as I am aware, any other similar metal or combination of metals)—1 per cent. or more—be added to the nickel and manganese, the resulting alloy has a higher electrical resistance than the alloy composed of nickel and manganese alone. For example, an alloy of 90 parts nickel and 10 parts manganese gives a specific resistance of about 36; if 10 parts of the nickel be displaced by 10 parts of copper, making an alloy of 80 parts nickel, 10 parts copper, and 10 parts manganese, a specific resistance of about 53 is obtained; where 20 parts of nickel are displaced by the same amount of copper, the resulting composition consisting of 70 parts nickel, 20 parts copper, and 10 parts manganese, has a specific resistance of about 60. Again, whereas a composition composed of 80 parts nickel and 20 parts manganese gives a specific resistance of about 65, I have found that the substitution of 10 parts of nickel by the same amount of copper, producing the alloy 70 parts nickel, 10 parts copper, and 20 parts manganese, gives a resistance of about 80; and an alloy consisting of 60 parts nickel, 20 parts copper, and 20 parts manganese, gives a resistance of about 90.

I am aware that alloys composed mainly of copper, with more or less manganese and a small amount of nickel, have been known and used. But these alloys are,

from a physical standpoint, essentially copper alloys, that is, copper is the principal ingredient. On the other hand, my alloys are composed essentially of nickel (and manganese) in which the nickel largely predominates, to which is added a comparatively small amount of copper (or its equivalent); my alloys are not in this sense "copper alloys." My present alloys differ further from these copper alloys in having a high melting-point and in producing conductors that are stable in their electrical properties.

The proportions above given are for the sake of illustration only, since the spirit of my invention consists, in the first place, in employing a large part, say 50 per cent. or over of nickel; in the second place, in employing at least two other ingredients in addition to this excess of nickel; in the third place, specifically, in having a substantial amount of manganese as one of the other two or more ingredients; and, finally, more specific still, in having a small but appreciable amount of copper (or an equivalent) as a third ingredient in addition to the manganese with the excess of nickel (and any other ingredients that may be present, if any).

Having thus described my invention, I claim:

1. An alloy of nickel, manganese and copper, the content of nickel being not less than 50 per cent. by weight of the whole, said alloy being characterized by having a specific resistance greater than an alloy of the first-named ingredients.
2. An alloy consisting of nickel not less than 50 per cent., manganese from 10 to 30 per cent., and the remainder of copper, said alloy having the characteristics specified.
3. An alloy containing copper and manganese with 50 per cent. or over of nickel.

The object of my invention is to provide holders, such as triangles, crucible-tongs tips, wire-gauze, and the like, employed in metallurgical laboratory work for supporting and handling the work, which shall enduringly withstand the destructive tendency of the high temperature to which they are subjected in use to destroy them and be particularly suitable for quantitative analytical work. When such holders are made of any base metal, the heat to which they are subjected in use rapidly destroys them by oxidation, and the metal, in being brought into contact with the heated platinum or porcelain of which the crucibles and other ware are made, discolors the surfaces, adding to the weight of the ware and thus rendering such holders unfit for quantitative analytical work. To avoid, more particularly, the last-named objection, such holders are sometimes made of platinum because it remains unaffected by the heat, but its cost renders it practically prohibitive for the purpose; and to enable a base metal to be used for avoiding that objection, sheathing the holder with fire-clay, fused silica, or the like, has been resorted to, but the metal soon "burns out," so that the holder is lacking in desirable durability.

My invention provides a holder, in the class referred to, which is devoid of these objections, and it consists in forming such holders of an alloy containing nickel or cobalt with chromium, and preferably also aluminium. I find that a holder composed of such an alloy effectually resists destruction by heat, and remains otherwise unaffected injuriously thereby during prolonged use, because of the very high melting point of the nickel or cobalt and the property of the chromium of reducing to the minimum the tendency of the nickel or cobalt to oxidize. The value, for my purpose, of aluminium as a part of the alloy is its effect under the influence of intense heat to produce an oxide which, combining with the oxides produced by the same in-

fluence from the other metals in the alloy, forms a continuous, very thin, dense and adherent non-scaling sheath or surface-coating, which protects the holder by insulating the body or interior of the structure against further oxidizing influence thereon. Moreover, the holder does not discolor. The alloy is best suited for my improved article of holder, as imparting to it in the highest degree the desirable property herein described, when composed of about 80 per cent. nickel or cobalt, about 18 per cent. chromium and about 2 per cent. aluminium.

1. A holder having the properties set forth, for receptacles employed in metallurgical laboratory work of the character described, formed of an alloy of chromium with a metal having the properties of nickel and cobalt.

2. A holder having the properties set forth, for receptacles employed in metallurgical laboratory work of the character described, formed of an alloy of nickel, chromium and aluminium.

See U. S. Patent 1,043,576 on page 303.

1,057,423, Haynes, April 1, 1913

This invention relates to a metal alloy more particularly designed for use in the manufacture of articles, such as tools or cutting implements, wherein are required the qualities of hardness, toughness and elasticity, together with the capacity of taking a high polish and receiving and retaining a sharp cutting edge.

In my prior Patent No. 873,745, issued December 17, 1907, I have described a binary alloy, consisting of cobalt and chromium, or other metal of the chromium group allied with chromium, or having properties like those of chromium; such metals of the chromium group embracing, in addition to chromium, tungsten, molybdenum and uranium. The binary alloy described in said patent possesses a high degree of hardness and toughness adapting it for use

in the manufacture of edged tools, cutlery and the like, has a high degree of resistance to oxidization and the corrosive action of the atmosphere and fumes occurring therein, and is capable of being forged, hammered, or otherwise worked into various forms of instruments and articles.

I have discovered that ternary and quaternary alloys, consisting of cobalt and two or more metals of the chromium group, possess particular value and qualities in many respects superior to those of the binary alloy set forth in said patent above mentioned. I have discovered, moreover, that such ternary alloys possess very valuable properties when composed of cobalt, chromium and tungsten, or cobalt, chromium and molybdenum, and that the quaternary alloys have also very valuable properties when composed of cobalt, chromium, tungsten and molybdenum.

An alloy made in accordance with my invention is composed of cobalt, chromium and one of the other metals of the chromium group, combined in the proportions substantially as hereinafter specified. The metals included in the chromium group, to which reference has been made, embrace, in addition to chromium, tungsten, molybdenum, and uranium. My experiments up to the present time have led me to prefer, of the metals of the chromium group, tungsten and molybdenum, as possessing the most desirable qualities as constituents of my alloy for the general purposes and uses intended, although it may be found that for different uses the other metal of the chromium group, to wit, uranium, may be employed to advantage, as one of the constituents of the alloy.

An alloy of cobalt, chromium and tungsten, which I have found to possess the desired properties for many articles or uses, contains chromium in a percentage of 15 per cent. or less, and tungsten in a percentage of 15 per cent. or less. Such ternary alloys may be readily forged at a red heat. Moreover, by using a considerable amount of care an alloy containing 65 per cent. of cobalt, 15 per cent. of chromium and 20 per cent. of tungsten can be forged to a considerable degree. All such ternary alloys possess valuable properties

in addition to those of the binary, or cobalt and chromium alloys, for many purposes, on account of the tungsten constituent, which gives to the alloy increased hardness and toughness, as well as a superior capacity to receive a sharp cutting edge and to retain the same under the most severe usage.

In a ternary alloy of cobalt, chromium and tungsten, if the chromium constituent equal 25 per cent. and the tungsten be present in the proportion of 5 per cent., the alloy is particularly suitable for wood-cutting tools, table knives and other cutlery. Such an alloy forges readily, shows a fine fracture, is very strong and elastic, and takes a fine cutting edge. The corresponding alloy, containing molybdenum in place of the tungsten, possesses similar properties. Moreover, both of these alloys possess the desirable qualities of the cobalt-chromium alloy described in my prior Patent No. 873,745 in being capable of taking a high and durable luster, and of resisting the oxidizing and corrosive action of moisture, acids, the atmosphere and corrosive fumes commonly occurring in the atmosphere.

If in a ternary alloy of cobalt, chromium and tungsten, the tungsten constituent be increased from 15 per cent. to say 50 per cent., the alloy becomes harder with increasing percentage of tungsten, and the same cannot be successfully forged after the tungsten constituent exceeds 25 per cent. A ternary alloy, containing from 25 per cent. to 50 per cent. of tungsten, 15 per cent. of chromium, the remainder being cobalt, makes excellent lathe tools, possessing to a high degree the qualities of hardness, toughness, and capacity of receiving and retaining a very sharp cutting edge. I have found that such lathe tools possess hardness, toughness and cutting qualities to a degree making them much superior to any steel lathe tools now produced. Moreover, such alloy is found to be capable of resisting to a large degree the corrosive action of moisture and the atmosphere. When the tungsten constituent exceeds 25 per cent., the alloy becomes sufficiently hard to readily scratch glass, and will even mark or score rock crystal. With per-

centages of 25 to 50 of the tungsten constituent, the ternary alloy, while not capable of being forged, may be readily fused, and lathe tools or other articles may be readily made by casting the same in the desired form and finishing by a suitable grinding operation. When the tungsten constituent in the ternary alloy exceeds 50 per cent., the alloy becomes very difficult to fuse, or fuses under very high temperatures, such as are usually obtainable only by the use of the electric arc, but the alloy containing such higher percentages of tungsten, while somewhat brittle, makes excellent lathe tools.

In the case of the ternary alloy, in which the molybdenum is used in place of tungsten, the same general conditions and characteristics, hereinbefore referred to in connection with the cobalt-chromium-tungsten alloys, are found to exist; excepting that the alloy reaches a condition in which it cannot be successfully forged when the percentage of molybdenum is somewhat smaller than is the case if tungsten is used as the third constituent. When the molybdenum constituent in such alloy is made to exceed 25 per cent., the alloy is very hard, and if the proportion of molybdenum does not exceed 30 per cent., the alloy is not only very hard, but likewise very tough and strong, and may be used with great advantage for lathe tools. When the percentage of molybdenum is as high as 40 per cent. or more, the alloy becomes exceedingly hard and quite brittle. It will cut persistently into glass, and a sharp corner of the metal, when drawn back and forth over the surface of a quartz crystal, will rapidly cut a deep groove in that material.

With respect to the ternary alloys of cobalt and chromium, with either tungsten or molybdenum as the third constituent, an increase in the percentage of the chromium constituent will give greater hardness and brittleness to these alloys even when they contain the tungsten or molybdenum constituents in the lower percentages. I have found, however, that the alloys described possess considerable toughness when the chromium constituent is present

to the extent of as much as 40 per cent., and if the tungsten or molybdenum constituent be low, that alloys useful for practical purposes may contain even a higher percentage of chromium. So far as my experiments have extended, moreover, I have found that advantageous results are obtained when the tungsten or molybdenum constituent is present in the alloy in the proportion, to the entire alloy, of from 5 per cent. to 80 per cent. In view of the fact, however, that an increase of the percentage, either of the chromium constituent, or of the tungsten or molybdenum constituent, tends to render the alloy more brittle, a smaller proportionate quantity of chromium will desirably be used when the proportion of tungsten or molybdenum is relatively large and vice versa. This is indicated by the examples above given of ternary alloys suitable in one instance for cutlery and the like, and the other instance, for lathe tools; to wit, in the first instance, 25 per cent. of chromium and 5 per cent. of tungsten (or molybdenum) with a corresponding percentage of the cobalt constituent, and in the second instance, 15 per cent. of chromium, and 25 per cent. of tungsten (or molybdenum) with a corresponding percentage of cobalt.

By making a quaternary alloy consisting of cobalt, chromium, and two of the other metals of the chromium group, namely, both tungsten and molybdenum, I have discovered that valuable alloys are obtained, such as are particularly suitable for high-speed lathe tools. For example, I have produced an alloy containing 5 per cent. of molybdenum, 25 per cent. of tungsten, 15 per cent. of chromium and 55 per cent. of cobalt, which, after being cast into a bar and made into a lathe tool, affords a tool which will cut cast iron and steel, without overheating of or injury to the tool, from 50 to 100 per cent. faster than a tool made from the best special or "high speed" steel now produced for such purposes. In the case of such quaternary alloys, in correspondence with the ternary alloys, the chromium constituent may be present in the proportion of from 5 to 80 per cent., or the tungsten and molybdenum constituents

together may be present in the same proportions of from 5 to 80 per cent., with such relative proportions of the chromium constituent, on the one hand, and the total quantity of the tungsten and molybdenum constituents, on the other hand, as to prevent an undesirable degree of brittleness in the alloy.

I have found, in general, that cobalt, in an alloy with two or more metals of the chromium group, produces a series of useful alloys, throughout a very wide range in the relative proportion of the constituents. In the case of admixtures of many other metals, the hardness rapidly increases with the increase in the proportion of one or more of the constituents, until the alloy becomes so brittle as to be unfit for practical use. As, for instance, if copper be alloyed with tin, an increase in the hardness of the alloy takes place, until, when the proportion of tin is materially over 10 per cent., the alloy becomes so brittle as to be unfit for practical use. To the contrary in the case of such other alloys, an increase in either the chromium, tungsten or molybdenum constituent, in the ternary and quaternary alloys referred to, even beyond the proportions hereinbefore generally stated (but so far as my experiments have gone, not exactly determined), will not make the alloy too brittle for practical uses. In other words, my tests have shown that, when the constituents of the alloys described are present, within the wide range of relative proportions stated, a series of alloys may be produced having novel and very valuable properties, and capable of use in the arts with great advantage and benefit.

It is to be understood that small quantities of other metals, or non-metallic substances, may be combined with the ternary and quaternary alloys described, such as will not injuriously affect the nature of such alloys, and which may to some extent modify their properties and render them more suitable for special requirements.

From the above, it will be understood that I have discovered new and useful ternary and quaternary metal alloys, consisting of cobalt and two or more metals of the

chromium group, and that these combinations or alloys possess particular and novel characteristics, as well as similar properties, whether composed of cobalt, chromium and tungsten; cobalt chromium and molybdenum; or cobalt, chromium, tungsten and molybdenum. It is also to be understood that any other metal of the chromium group may be added to the alloy or substituted in the alloy for either one of the metals of the chromium group hereinbefore particularly specified.

Inasmuch as an alloy having the same general characteristics may be obtained by embodying cobalt and chromium with either one of the other metals of the chromium group, to wit, tungsten or molybdenum (forming a ternary compound) or with two of such other metals of such chromium group, to wit, tungsten and molybdenum (forming a quaternary compound), it is to be understood that the term "metal allied with chromium" as used in certain of the appended claims, is intended to mean, or to include in a general sense, either one or more than one of the specific metals, other than chromium, known or commonly designated as metals of the chromium group.

I claim:

1. A metal alloy composed of cobalt and at least two of the metals of the chromium group.
2. A metal alloy composed of cobalt, chromium, and other metal allied with chromium.
3. A metal alloy composed of cobalt, chromium and one other metal of the chromium group.
4. A metal alloy composed of cobalt, chromium and tungsten.

1,057,753, Marsh (Assigned to Hoskins Manufacturing Company), April 1, 1913

My invention relates to an electrical resistance element adapted for general use, but primarily for the production

of heat in heating devices. In devices of this character the factor of principal importance is durability, which it is practically impossible to predetermine except by actual test under conditions approximating those of use. By such test I have discovered that a resistance element formed of an alloy of iron and aluminium possesses great durability, combined with sufficient resistivity that it may conveniently be built into translators of the character specified, its resistivity being 94 michroms per centimeter cube when 10 per cent. aluminium is used.

In practice I prefer to use an alloy in which the aluminium is from 5 to 10 per cent. The addition of larger quantities of aluminium renders the alloy difficult to roll, but the advance in metal working knowledge may make it possible to work higher percentages. Of course, it will be understood that my invention comprehends not only the use of the alloy specified, but as well, the same alloy with additions of various other metals, for I have learned that when the suitability of a resistance element is once discovered, it may suffer the addition of considerable quantities of other metals without being materially injured, or, in fact, changed to any noticeable extent, although in some cases the addition of elements produces quite extraordinary changes.

1. An electrical resistance element adapted to withstand a high temperature formed of an alloy consisting of iron and aluminium.

2. An electrical resistance element adapted to withstand a high temperature formed of an alloy consisting of iron and aluminium, the aluminium being in the proportion of from 5 to 10 per cent.

1,057,754, Marsh (Assigned to Hoskins Manufacturing Company), April 1, 1913.

My invention consists in a novel resistance element adapted for general use for which articles of the class are

intended, and more especially suited for use in heating appliances. For this purpose, it is well known that the principal requirement is durability, and the resistivity should be high enough to enable the requisite heat to be developed in the space afforded in commercial appliances. The durability of a wire of a resistance element maintained at a high temperature by internally developed heat caused by the passage of an electric current depends upon a very large number of factors and can be determined only by test.

In my Patent No. 811,859, wherein I describe a resistance element of nickel and chromium, and mention as desirable, nickel chromium alloys with the chromium in the percentages of 10 and 15, I also stated that iron was not suitable for my purpose, and in working with iron as a substitute for nickel in the proportions therein mentioned, the facts are as stated therein. I have since discovered, however, that there is a somewhat sharp change in the durability of the alloy when the chromium is used in high percentages, as from 20 per cent. upward, and when 25 per cent. chromium is used, the alloy is extremely durable, although it is a trifle less durable than the exceedingly resistant nickel chromium alloy therein described. However, for use at low temperatures, say at 800° C., and particularly where the element is to be used in large quantities and price is a consideration, the iron chromium composition is very desirable. It has a resistivity of approximately 56 michroms per centimeter cube, which is sufficiently high for most uses.

The resistance element of the composition above mentioned can, when suitable materials are used, be drawn into wire form as high as 35 per cent. chromium, as far as I know now, but with the rapid advance of rolling methods, and the possibility of obtaining purer metals, much higher proportions may be drawn in the future. Resistance elements containing from 20 to 35 per cent. chromium are generally uniform in character, but with slightly greater life and slightly higher resistivity as the chromium in-

creases, and it is not to be anticipated that a further increase of chromium within any limits which may be found workable in the future, will materially change the properties. Manifestly, still greater proportions of chromium might be used if cast grids or the like were used.

I claim:

A resistance element adapted to withstand a high temperature formed of an iron chromium alloy in which the chromium is at least 20 per cent.

1,096,655, Weintraub (Assigned to General Electric Company), May 12, 1914

The present invention comprises new and useful alloys of platinum and either tungsten or molybdenum, or of the three together, having the property of being malleable, resisting oxidation and having besides greater mechanical strength than platinum.

The new alloys embodying my invention comprise at least about 20 parts of platinum, the remainder being tungsten or molybdenum, or both. For the preparation of the alloys I prefer to use the metals in a ductile state. One mode of procedure is to use very thin wires of the respective metals, the wires being combined in proper proportions. The wires are twisted or braided intimately together and heated to the melting point in an inert environment, for example, by the heat of a mercury arc until alloying takes place. Vapor arc furnaces suitable for melting the metals in contact with one another are shown in my Patents Nos. 997,882 and 1,068,615. The alloys thus prepared resemble platinum in appearance, but in tensile strength and hardness are superior to platinum. The permanency in air and good wearing properties of these new alloys constitute properties making the alloys superior to platinum and iridium for many purposes, particularly for scientific instruments, jewelry, electrical contacts, and the like.

I claim :

1. A malleable alloy which is permanent in air comprising tungsten and platinum, the latter constituting at least about 20 per cent of the alloy.

2. A malleable alloy comprising about 20 to 60 parts of platinum and about 80 to 40 parts of tungsten, said alloy being characterized by permanence in air and by being more refractory and harder than platinum.

1,101,534, Graf, June 30, 1914

My invention relates to an improvement in alloys, and has for its object to provide a composition of metal which may be employed as a substitute for platinum in various instances, such as electrical contacts, and the like, and which will be cheaper to manufacture, and can consequently be sold at considerably less price than the cost of platinum.

The composition consists of the following ingredients, to wit: platinum, $4\frac{1}{2}$ ounces; silver, $2\frac{1}{2}$ ounces; gold, $1\frac{1}{2}$ ounces; sulphide of antimony, 16 ounces; sodium chloride, 4 ounces; crystallized vitriol, $1\frac{1}{2}$ ounces; copper (pulverized) $1\frac{1}{2}$ ounces; sulphur distillate, $1\frac{1}{2}$ ounces; mercury, $1\frac{1}{2}$ ounces.

In carrying out my invention, the vitriol, sulphide of antimony and sodium chloride are placed in a retort and thoroughly baked, and then mixed with the platinum, silver, gold and copper, and melted together, to which is added the sulphur distillate and mercury. These ingredients when allowed to cool form my alloy. The antimony and mercury being more or less volatile at the temperature at which the other metals are molten, but slight traces of these ingredients remain in the alloy as a finished product. By this composition, I produce a metal which can be used in connection with electrical appliances and the like, as well as for other purposes to which platinum is adapted. This metal can be made much cheaper than platinum and

can be employed as a substitute for platinum in the manufacture of various devices and appliances wherein platinum is usually employed.

The crystallized vitriol is prepared as follows: Powdered white vitriol (zinc sulphate) dissolved in alcohol is placed in a retort and subjected to heat of not less than 212° F., from whence it is distilled to a receptacle and allowed to remain until crystallized, the time required to crystallize being approximately twenty days.

The sulphur distillate is prepared by placing a quantity of powdered sulphur in a retort and subject the same to a heat sufficient to cause a vapor to arise therefrom, this vapor is distilled into another receptacle and permitted to remain for a period of approximately twenty days, the distillate becoming more or less of an oily nature and is sometimes termed sulphur oil.

I am aware that changes may be resorted to in the method of mixing the ingredients and the proportions or quantities used.

I claim:

An alloy consisting of platinum, 45 per cent.; gold, 15 per cent.; silver, 25 per cent., and copper, 15 per cent.

See U. S. Patent 1,115,239 on page 34.

See U. S. Patent, Reissue 13,961, page 274.

See U. S. Patent 1,150,113 on page 39.

See U. S. Patent 1,151,160 on page 84.

1,130,077, Eldred, March 2, 1915

This relates to a contact element having a layer of platinum of a peculiar hard texture firmly united to a foundation of a metal of the iron class, as nickel, iron, steel, etc.

The joinder is of the nature of a weld union, so that the joined metals can be extended by rolling, hammering, drawing, etc., which operations give the platinum a hard, dense and firm texture.

In practice a bar or sheet of platinum is laid on a bar or sheet of the foundation metal, and the assembled metals quickly and cautiously heated to a temperature where the surface only of the foundation metal melts. This causes their joiner. The heating is preferably from above and all gases should be extricated. With a comparatively wide, thin sheet of platinum, it may be perforated in the middle to allow exit of gases.

Instead of direct joiner, a linking layer of copper, gold, or silver may be employed, this layer first being welded on to the foundation. Nickel is suitable as a foundation metal.

In punching, the platinum may be flowed or arched some distance down the shank of foundation metal.

I claim :

1. The process of producing platinum capped contact elements which comprises producing an integral union between a layer of platinum and a layer of stiff and strong metal by means of a fused layer of linking metal, rolling down the joined metals to a greater thinness to compact the platinum and produce a compound plate having a thickness substantially equal to the length of a contact point and cutting contact elements therefrom by a vertical cut.

1,166,129, Heyl (Assigned to Commercial Research Company), Dec. 28, 1915

This invention relates to improvements in terminals for contact or spark devices.

It has been the usual practice heretofore to provide a contact device or spark point in electrical apparatus with a terminal facing or cap of platinum in order to insure that such facing or cap will remain clean and unaffected by electric sparks which may be formed between such terminal facings. Platinum has been employed for such terminal facings particularly on account of its high melting point

and its non-oxidizability or chemical inertness under various conditions of service, whereby it maintains a good metallic surface even though heated to a relatively high temperature by the sparks. Hardness has generally been considered an advantage in a terminal facing for a contact device where the points are moved into and out of contact with each other. In fact it has sometimes been the practice to alloy a certain percentage of iridium with platinum in order to produce a terminal facing of greater hardness. I have found, however, that in practice it is difficult to make the contact surfaces fit exactly to each other throughout their entire extent, and therefore with very hard terminal facings any defect in accurate fitting of the meeting surfaces becomes a disadvantage, because the surfaces do not thereafter wear to a good contact with each other, or at least not for a long time.

I have found that a terminal facing for spark points or contact devices comprising a mixture of palladium and silver has important advantages over anything heretofore known to me. Palladium is a material having a high melting point, but when alloyed with silver the melting point of the alloy is very considerably reduced. This apparently would be a great disadvantage and would seem to indicate that such an alloy would not be satisfactory for the purposes named. I have found, however, that as the thermal-conductivity of silver is very high, when mixed with palladium it gives to the alloy a thermal-conductivity considerably above that of palladium. Owing to this thermal-conductivity the heat generated by the spark is conducted away from the contact surface rapidly enough to insure that the surface portion will not reach a temperature above the melting point of the alloy. Where the current passing through the terminal facings does not have a great density, the terminal facings may be formed of an alloy composed principally of silver with a relatively small amount of palladium. In fact I have found that an alloy of silver with 2 per cent. of palladium will give satisfactory results under many circumstances. When, however, the spark

points or contact devices are to be exposed to an atmosphere containing sulphur compounds, the percentage of palladium should be increased. I have found that an alloy of silver with 5 per cent. of palladium or more is substantially inert in any atmosphere likely to be encountered in practice.

A further important feature of my invention, however, consists in a special proportioning of the constituents of such an alloy, and is not limited to an alloy of palladium and silver. It will be noted that palladium is a non-oxidizable metal having a high melting point, but a low thermal-conductivity. Silver, on the other hand, is a metal having a comparatively low melting point, but a high thermal-conductivity. When, in an alloy of palladium and silver, the percentage of palladium is increased, the melting point of the alloy is increased, but its thermal-conductivity is decreased. At a certain intermediate point between the maximum and minimum proportions of palladium, the alloy will have the maximum resistance to spark erosion for an alloy of such components. The particular percentage which produces this maximum above mentioned may be considered as a critical proportion, because if the percentage of palladium be increased the thermal-conductivity of the alloy is decreased, and hence, for this reason its resistance to spark erosion is reduced, whereas if the percentage of silver is increased from said critical proportion, the melting point of the alloy is decreased, and for this reason its resistance to spark erosion is reduced. I have found that such a critical proportion for a palladium-silver alloy occurs with about 60 per cent. of silver and 40 per cent. of palladium. When an alloy of this composition is used for the terminal facings of contact devices or spark points the result will be entirely satisfactory with the greatest density of current encountered in practice, while at the same time such an alloy is substantially mechanically inert and will not be affected by the reacting components of any atmosphere likely to be encountered in practice. It is to be understood that considerable varia-

tion from the critical proportion may obtain in practice without material disadvantage. In fact I have found that 50 to 80 per cent. of palladium and 50 to 20 per cent. of silver form an alloy particularly satisfactory for general use. It is clear that so far as this feature of my invention is concerned, any non-oxidizable high melting metal of low thermal-conductivity may be combined with a low melting metal of high thermal-conductivity in substantially the proper critical proportion so as to produce an alloy having the maximum resistance to spark erosion.

A terminal facing for a contact device made of palladium-silver alloy may be somewhat softer than pure platinum, whereby considerable difficulty in fitting the surfaces to each other is avoided owing to the fact that as the composition is somewhat softer and more malleable than platinum, the hammering of the contact surfaces against each other in practice will force an accurate fit of the contact surfaces, and thereby insure a satisfactory operation of the contacts, even when not accurately fitted initially. Of course, the contacts should not be so soft as to materially flatten out after the surfaces have been brought into contact throughout.

In practice I have found that terminal facings comprising an alloy of palladium and silver are as satisfactory as pure platinum facings, while at the same time they are more readily worked into shape and attached in place by soldering or the like.

While I have particularly referred to a terminal facing consisting of palladium and silver alloy, it is to be understood that my invention in its broadest aspect does not exclude such an alloy containing other constituents in addition to the palladium and silver.

What is claimed is:

1. A terminal for an electric spark or contact device comprising palladium and silver.

2. A terminal for an electric spark or contact device consisting of an alloy of palladium and silver.

3. A terminal for an electric spark or contact device consisting of an alloy of palladium and silver containing from substantially 40 to 80 per cent. of palladium.

1,168,074, Hunter, Jan. 11, 1916

This invention relates to electric resistance materials and involves the production of a new alloy for use in the manufacture of electric resistance elements of various kinds.

In accordance with the invention, an alloy is produced which may be used at relatively low cost in the production of electric resistance elements possessing to a marked degree the two primary requisites of such resistances, namely, high electrical resistivity and low temperature coefficient of resistance. The new alloy is also specially adapted for use in resistance elements for the reasons that it has a high melting point, will not corrode when worked hot and has a low thermo-electromotive force against copper. The new alloy made in accordance with the invention consists of nickel, copper and chromium, the proportion of nickel being large relatively to the proportion of copper and chromium.

Alloys of nickel and chromium have been used heretofore as a resistance material and the results thus obtained are very good. I have discovered, however, that by properly alloying nickel, copper and chromium, a resistance material may be produced which is much more efficient and desirable. I have found that though the addition of chromium to copper has but little effect upon the electric resistance thereof, the addition of chromium to an alloy of copper and nickel in the proper proportions increases the resistance of the alloy far beyond that to which the resistance of nickel is raised by alloying chromium therewith. Furthermore, the addition of chromium effects a reduction

in the temperature coefficient of resistance of the alloy. Otherwise stated, I have found that the addition of a small proportion of copper to an alloy of chromium and nickel results in materially increasing the resistivity of the alloy. It is important, however, that the proportion of copper should be small as compared to the nickel, since increases in the proportion of copper beyond a critical point result in lowering the resistance of the alloy below what it would be if no copper were present.

In the alloy which I have found to be most suitable for general use as a resistance material, the nickel and copper are in the proportion of 75 to 95 parts of nickel to 25 to 5 parts of copper. Good results may be obtained outside this range of variation, especially when but little chromium is used, but I find this relation of the nickel and copper elements to be best. As the proportion of nickel is increased beyond 95 parts of nickel to 5 parts of copper and as it is decreased below 75 parts of nickel to 25 parts of copper, a marked decrease occurs in the resistivity of the alloy. The amount of chromium added to the mixture is small compared to the nickel; preferably it is from 15 to 25 parts by weight of chromium to 100 parts of nickel and copper. The higher proportions of chromium have a beneficial effect in increasing the resistivity, but then practical difficulties in the mechanical treatment of the material become more pronounced. An amount of chromium less than that above named as being best would increase the resistance of a given copper-nickel mixture and is especially desirable when the proportion of copper is made larger than that above indicated for any reason, but the resistance of the material thus produced would be less than that obtained by employing the larger amount of chromium in combination with nickel and copper in the proportions above indicated.

I have had particularly good results with an alloy consisting of 85 parts of nickel to 15 parts of copper, with 20 parts of chromium to 100 parts of nickel and copper. Such an alloy has been found to have a resistivity of about 113

microhms per centimeter cube at 20° C. and to have at that temperature a temperature coefficient of resistance of about 0.000078 ohms per degree centigrade per ohm.

What I claim is:

1. An electric resistance material consisting of an alloy of nickel, copper and chromium, the nickel and copper being in the relation of 75 parts to 95 parts of nickel to 25 parts to 5 parts of copper; substantially as described.

See U. S. Patent 1,169,753 on page 77.

1,175,172, Oakley, March 14, 1916

The present invention relates to valves adapted for use within the cylinders of internal combustion engines, to control the intake of gases thereto, and the exhaust of gases therefrom.

It is an object of the present invention to provide a valve possessing the characteristics of strength and ability to resist high degrees of heat as to render its use in the cylinders of engines of this type free from the attendant difficulties which are common to valves now ordinarily used.

The valve is made from an alloy, the constituents of which are approximately as follows:

Nickel	About 67%
Iron	From 1% to 5%
Copper	Remainder

Such an alloy contains but a trace of carbon; it has been found to possess a coefficient of expansion under the application of heat substantially identical with that of the steels ordinarily used in the manufacture of gas engine puppet valves, and also with that of cast iron of which the cylinders are usually made. This alloy is distinguished further by its ability to resist the destructive action of high temperatures, and its freedom from the gaseous corrosion ordinarily produced in other metals by the heating

of the same above a red heat. It has been found that the alloy does not scale, as does steel, under high temperatures, but that the oxide forms a thin adherent coating. When heated to the maximum temperatures attainable in the ordinary operation of gas engines, this alloy retains approximately 80 per cent. of its elastic limit and tensile strength as compared with approximately 71 per cent retained by the best high grade steel at such temperatures. Furthermore, the virtual freedom of this alloy from any carbon content, as compared to the appreciable carbon content of all steel and irons used heretofore in the production of valves of this type, has the effect of eliminating a very potent agency in the production of a deposit of carbon on the valve, namely, the tendency of the carbon produced by combustion of the gas to unite with any carbon contained in the highly heated valve.

I claim:

1. A valve for internal combustion engines, made from an alloy comprising a large proportion of nickel, and a small proportion of iron.
2. A valve for internal combustion engines, made from an alloy chiefly consisting of nickel and copper.
3. A valve for internal combustion engines, made from an alloy comprising approximately 67 per cent. of nickel and 30 per cent. of copper.

1,175,724, Driver, March 14, 1916

My invention relates to chromium alloys intended primarily for use as an electrical-resistance element.

The purpose of the invention is to produce a novel class of non-oxidizing alloys that are ductile and malleable, with a high electrical-resistance and a low temperature-coefficient.

More specifically, a preferred form of my invention is based on the discovery that whereas a substantial per-

centage (say, 5 to 10 per cent.) of chromium added to copper alone gives such inferior mechanical qualities that the material is practically valueless, yet when the chromium is to be added to a mixture or alloy of copper and some other metal such as manganese or nickel, the chromium may be added in substantial quantities (say, from about 10 per cent. to almost 20 per cent.) and yet produce an alloy which is ductile and malleable, and which affords a relatively high resistance to oxidation; moreover, the alloys of this new class present a high electrical resistance and have a low temperature-coefficient, so that they are particularly suitable for electrical-resistance purposes.

Other things being equal, increase in the percentage of chromium increases the resistance to oxidation, but decreases the workability of the composition. With as much as 20 per cent. of chromium, the material appears rather difficult to work; but with around 10 per cent. of chromium, it works easily, and such 10 per cent. chromium alloys are found to be very suitable for electrical-resistance purposes. Even an amount of chromium as low as 2 per cent. produces a marked effect.

Broadly, my invention contemplates an alloy containing chromium, more specifically chromium and copper. I prefer, however, an alloy comprising chromium and copper with some other metal or metals, and particularly such three-metal alloys in which there is a substantial percentage of the chromium. The preferred amount of chromium is around 10 per cent., although the percentage may vary as between, say, 2 per cent. and 20 per cent.

As one example, take about 45 parts, by weight, of copper, about 45 parts of nickel, and about 10 parts of chromium, and fuse them together in any convenient manner. As another example, take about 50 parts by weight, of nickel, about 30 parts of copper, about 10 parts of manganese, and about 10 parts of chromium, and fuse them together in any convenient manner. The lowest temperature coefficients have been obtained where the nickel and copper are used in about equal amounts, and as the nickel

is increased the alloy becomes harder. But these nickel-copper-chromium alloys, with or without manganese, give very good results, both where the nickel predominates and where the copper predominates. The effect of the addition of chromium to alloys containing nickel and copper, increases as the percentage of the nickel increases. In other words, it seems as though the chromium has a greater effect, for electrical resistance, upon the nickel than upon the copper.

Having thus described my invention, I claim:

1. An electrical-resistance element consisting of an alloy containing copper and nickel and manganese, with from about 2 per cent. to about 10 per cent. of chromium.
2. An electrical-resistance element consisting of an alloy containing copper and nickel and manganese, with a substantial percentage of chromium.

1,203,180, Brix (Assigned to American Alloys Co.), Oct. 31, 1916

The description is the same as U. S. Patent 1,203,555 on page *44*.

I claim:

1. A metal alloy containing one or more of the metals of the nickel group such as nickel not under 55 per cent., one or metals of the chromium group such as chromium not over 30 per cent., silicon not over 10 per cent., and one or more metals that will act on the contents of the alloy to assist in melting the same to render the alloy homogeneous, such as copper.

See U. S. Patent 1,203,555 on page *44*.

1,211,943, Hunter, Jan. 9, 1917

My invention relates to electrical resistance material, and particularly to that class of electrical resistance ma-

terial wherein great durability is the predominant characteristic in connection with resistivity relatively higher than that of many metals, for example, silver, copper, etc. When it is desired to derive heat directly from electricity, the electricity is passed directly through a resistance material, the heat generated being proportioned to the resistance and the current. It is desirable that the resistance material be operated at as high a temperature as practicable, and the problem to be solved is to secure a material which has a relatively high resistance and which, at the same time, will not become oxidized or otherwise altered by the action of the air and moisture while it is at high temperature. In other words, durability is an essential characteristic. Another desirable characteristic is that the temperature coefficient of resistance must be low. The best known resistance material, so far as durability is concerned, is the element platinum. The high cost of this element renders its general use as resistance material prohibitive. While platinum has a higher resistance than some elements, its resistance is not great as compared with some alloys of less durability. The resistance materials comprising these alloys that are well known have sufficient durability to render them practicable and give them a higher resistance than that of platinum, but they can only be prepared at great cost, because of the great value of their basic constituents, and because of the difficulty experienced in reducing the material to shapes and sizes necessary for their general application in the heating devices.

The alloy which I have discovered and which embodies my invention is superior to the expensive alloys above mentioned, so far as durability, resistivity and temperature coefficient of resistance are concerned, but it, nevertheless, is cheaply produced, by reason of the low cost of its basic and fundamental constituent, iron, and by reason of its ready workability. It has been the belief, heretofore, that iron was not a suitable base or foundation for a practical resistance material, because of its being readily destroyed

by exposure to air at high temperature, even when alloyed with elements known to possess the property of resisting oxidation at high temperatures. It is well known, however, that the properties of an alloy cannot be foretold from a knowledge of the properties of the constituents of the alloy derived from observation of the properties of those constituents under variations of conditions, either when they are substantially pure or when they are alloyed with other materials.

My invention comprises an alloy wherein the base or foundation is iron, which, as above noted, has heretofore been believed to be unsuitable, with which is alloyed nickel and chromium, the proportions of nickel and chromium being respectively less than the proportion of iron. It has been suggested that chromium will increase the resistance of an alloy and, at the same time, increase its durability, but it is well known that the addition of chromium in all percentages will not bring about these desirable results, but, on the contrary, the addition of chromium in certain percentages will exert an undesirable influence upon resistivity and durability.

I have made a great number of experiments with alloys containing chromium, iron and nickel. My experiments have had for their object the determination of the resistivity and durability of alloys in which various amounts of chromium have been added to alloys having varying proportions of iron and nickel. The alloys which were tested comprised a number of series, in each of which the chromium content remained constant and the proportions of iron and nickel varied. Each alloy can be considered as comprising an iron-nickel portion and a chromium portion, the iron-nickel portion being always made up of 100 parts, the proportions of which varied from substantially 100 parts iron and 0 parts nickel to 100 parts nickel and 0 parts iron. Each series of alloys above referred to was formed by adding a constant quantity of chromium to a varying iron-nickel alloy, the constant quantity of chromium in one series differing from that in another and

varying substantially from 10 to 40 parts for each 100 parts of the iron-nickel portion. In each series I found that the best results are obtained with an alloy in which the iron-nickel portion has from 75 parts nickel and 25 parts iron to 25 parts nickel and 75 parts iron and the chromium portion comprises 20 to 40 parts of chromium for each 100 parts of the iron-nickel portion. Very desirable alloys are found in the field in which the iron-nickel portion is made up of 50 to 60 parts of iron and 50 to 40 parts of nickel and the chromium portion varies from 25 to 35 parts of chromium for each 100 parts of the iron-nickel portion. As a specific instance, I have found that an alloy containing 30 per cent. nickel, 47 per cent. iron and 23 per cent. chromium gives excellent results. This alloy has as high resistivity as is desirable and has great durability, and it is at the same time, very easily worked and much cheaper than known alloys having equally desirable properties. This alloy is readily compounded, and great uniformity of results is obtained.

It is to be understood that, where I have mentioned chromium, other elements of the group to which chromium belongs can be substituted within the scope of my invention. Iron, nickel and cobalt are in the same group of elements, but it has been believed heretofore that iron could not be substituted for nickel. In my alloy, however, I have successfully made this substitution by using the proportions herein set forth of the various elements. It is to be understood, however, that cobalt may be substituted for nickel within the scope of my invention, and it is to be understood that whenever I refer to a metal having the properties of nickel and cobalt, in the claims, I intend only the metals nickel and cobalt, inasmuch as they have common properties, suitable for my purposes, but which can not be defined by any single term. The metals of the chromium group, when alloyed in proper proportions with other metals, impart desirable properties thereto. However, at present, I believe that chromium is the most desirable of

the metals of this group. It has thus been found to be satisfactory for my purposes.

It is apparent, therefore, that I have produced an alloy having an element for a base which was believed formerly to be unsuitable, and which alloy, nevertheless, possesses the necessary characteristics to a marked degree.

I claim:

1. An electric resistance material comprising a strip, strand or filament formed of an alloy of iron, a metal of the chromium group, and a metal having the properties of nickel and cobalt, no other metal being present in such proportions as to affect the qualities of said alloy as a resistance material.

2. An electric resistance material comprising a strip, strand or filament formed of an alloy having a major portion of iron, a metal of the chromium group, and a metal having the properties of nickel and cobalt.

1,217,578, Driver, Feb. 27, 1917

My invention relates to alloys intended especially for electrical resistances. The object of the invention is to produce alloys which can be readily soldered, and to produce alloys of a closer and more cohesive grain in such electrical resistances as now have a tendency toward a separation of the grains, under working, thereby to render commercially available certain resistance-alloys which are not at present commercially useful or usable, owing to their friability or tendency to break or separate during the process of rolling and drawing.

In this art, an alloy is regarded as suitable for an electrical-resistance element if it has an electrical resistance of thirty or more michroms per cubic centimeter.

I have discovered, by study and experiment, that tin can be used as an ingredient of such alloys to good advantage in securing the objects above set forth. The addition of a

proper amount of tin gives to the particular alloy at least two most desirable and distinct qualities which it did not theretofore possess:

First, although copper-manganese, copper-manganese-aluminium, copper-nickel, copper-nickel-manganese, etc., alloys have been used for electrical resistance purposes, it has been found difficult to solder in a permanent manner most if not all of these alloys. By the addition of a proper amount of tin, this difficulty can be and is to a great extent overcome. With reference to the proper amount of tin to be used in a particular composition (*e. g.*, one where in copper and manganese forms the body of the alloy), I have found about five (5) per cent. of tin to be very efficient, though less may be employed with some benefit, and a larger percentage can be used if desired. For instance, an alloy of copper 83 per cent., manganese 12 per cent., and tin 5 per cent., gives a high electrical-resistance, a low temperature-coefficient, a low thermo-electric effect against copper, and good solderable quality.

Second, in some alloys, particularly those employing nickel and manganese (*e. g.*, copper-nickel-manganese) the grains of the composition are in themselves often strong and tough, but there is little cohesion between the grains, and the alloy as a whole is not sufficiently strong and ductile to withstand rolling and drawing. For rendering such alloys workable, less tin is required than for rendering them capable of being soldered. I have found that the addition thereto of from 1 per cent. to 2 per cent. of tin, produces a marked improvement in ductility and cohesion and permits the working to be carried on to a greater extent and with more satisfactory results. But, if it is desired to render the alloy both workable and capable of being soldered a larger amount than from 1 to 2 per cent. of tin may be used.

The percentages above set forth are given merely as examples of the amount of tin which may be used to advantage in particular cases, but my invention is not limited

to such percentages, and the amount of tin used can be varied to a considerable degree without departing from the spirit of my invention and the scope of its usefulness.

Having thus described my invention, I claim:

1. An electrical-resistance element consisting of an alloy containing copper and manganese, and having about 5 per cent. of tin.
2. An electrical-resistance element consisting of an alloy containing copper and some other ingredient, and having about 5 per cent. of tin.

*1,221,769, Cooper (Assigned to the Cooper Company),
April 3, 1917*

This invention consists of an alloy of zirconium and nickel or cobalt, with or without the addition of another metal, all substantially as herein shown and described and more particularly pointed out in the claims.

I have found by careful experimentation that ductile metals such as cobalt or nickel may be hardened or toughened to a variable degree by the addition of more or less of the metal zirconium, and that the alloy and a product made therefrom is also resistant to acids and alkalis, and possesses high electrical resistance, and when heated to about 1150° C. there is formed on the outside a thin adherent coating of oxide which prevents further oxidation of the metal.

Where a small percentage of zirconium is used, for example, 2 to 10 per cent., and the balance nickel, the alloy takes a fine and lasting cutting edge and is suitable for knives, razors and other cutlery. In an alloy of zirconium and nickel comprising 8 per cent. to 15 per cent. of zirconium and the remaining per cent. nickel or cobalt, the melting point of the alloy is decreased below that of nickel, or about 1400° C., and the electrical resistance increased compared with nickel, while an increase in hardness and

resistance to oxidation and corrosion is also effected. Cutlery made of the alloy remains bright and clean even under the action of acids found in such fruits as lemons, oranges, etc., and cutting tools or implements made therefrom are far superior to steel tools. The alloy may be forged or worked at red heat, and is also applicable to electrical uses. That is, it may be used with advantage in thermoelectric junctions, and as a resistance element in heating appliances, such as electric toasters, irons, stoves, and furnace windings. In producing the alloy, the technical oxide of nickel is suitable for use without purification.

Where the zirconium content is increased to say 16 to 30 per cent., the hardness of the alloy is greatly increased. For example, with 25 to 30 per cent. of zirconium and the balance of nickel, the alloy is of exceptional utility when formed into cutting tools. For example, a tool of this alloy easily cuts glass. The melting point and tensile strength is lowered by increased amounts of zirconium, and the alloy cannot be worked by ordinary methods involving forging, drawing and rolling, but may be cast to produce lathe or cutting tools for working alloy steels, cast iron, drill rod and bronze. Even high speed steel is easily cut at a higher speed than with the tools now in use, and without appreciable wear or loss in temper of the cutting tool.

The high speed steels now used in making cutting tools contain iron, tungsten, a small amount of chromium or vanadium, and more or less carbon. Care is necessary in grinding tools made of high speed steel to prevent burning of the tool, and loss in temper and dulling of the cutting edge also takes place when operating the cutting tool at high speed. My alloy is free from carbon and iron and I have found by exhaustive tests that it is impossible to burn a tool made of my alloy, either when cutting at a high speed or in grinding the tool, and that no special care need be taken in grinding operations. I have also found that the wear in grinding is only about one-tenth of that of the best high speed steel, which means a great saving in material, and that the tool remains white notwith-

standing grinding or high speed operations. Moreover, my alloy can be manufactured at a lower cost than tungsten steels, as a zirconium ore with an oxide content of about 73 per cent. is obtainable in the market at a much lower price than tungsten ores.

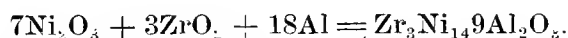
With the zirconium content increased to 16 to 30 per cent., the alloy is given a very low melting point, approximately 1150° C., and where it is necessary to operate tools or dies of this alloyage at a red heat an additional metal may be incorporated to raise the melting point of the alloy to the proper degree necessary to insure hardness at higher temperatures. For this purpose a small amount of one or more of the metals of the chromium group may be advantageously added, and in my experiments and tests molybdenum appears to give the best results of any of the metals of the chromium group, and I have made alloys with various percentages of molybdenum up to 35 per cent., with as high as 25 per cent. of zirconium and the balance nickel or cobalt. For general use, however, only a sufficient amount of molybdenum or its equivalent need be added to establish the melting point of the alloy at about 1600 C. as I find this to be sufficiently high to impart the necessary heat resisting qualities for nearly every practical purpose, and at the same time low enough so that the worn or used tools may be easily remelted and cast into bars or tools for further use. This alloy possesses sufficient tensile strength so that it is possible to permit the tool to be used with a long overhang. An alloy of this type is preferably composed of about 10 per cent. molybdenum, 25 per cent. zirconium, and 65 per cent. nickel or cobalt.

Iron cannot be used to replace the nickel or cobalt in the alloy as the alloys of zirconium iron which I have made are too soft for the purpose stated. Titanium (another member of the same group as zirconium) may be alloyed with nickel, but this substitute does not yield advantages comparable with zirconium, and nickel has proven superior to cobalt.

These alloys have the peculiar property of self-hardening and are ready for use when cast; that is, no treatment is necessary before use nor are they improved by any tempering process known to me. The alloy takes a beautiful polish which is not affected by gases of the atmosphere, nor corroded by alkalis or cold concentrated nitric, sulphuric, hydrochloric, or boiling sulphuric acids, or cold dilute acids.

Chromium, uranium, or tungsten may be added to zirconium and nickel or cobalt, and in this way make ternary and quaternary alloys of perhaps greater hardness than the above, and I have made alloys containing zirconium-nickel and tungsten, with as high as 25 per cent. tungsten, and also uranium, but so far the increased cost has not been overcome by a sufficiently better alloy to justify the use of these added elements.

I have found it is possible to produce these alloys by various methods, one being the alumino-thermic method, and a typical example for the reaction in an alloy containing about 25 per cent zirconium may be expressed as follows:



If the ore is substituted for the oxide of zirconium a correspondingly larger amount must be used.

What I claim is:

1. An alloy comprising zirconium and a preponderating amount of nickel and cobalt, the zirconium content being not less than about 2 per cent. and not more than about 40 per cent. of the composition.
2. A cutting tool composed of a self-hardening alloy containing 2 per cent. to 40 per cent. of zirconium together with a preponderating amount of nickel.
3. An alloy, comprising zirconium and a preponderating amount of a metal having the properties of nickel or

cobalt, with the addition of a small amount of one or more of the metals of the chromium group not exceeding 35 per cent. of the composition.

1,223,002. Sandell (Assigned to Herbert S. Mills, of Chicago, Illinois), April 17, 1917

My invention relates to improvements in metal compositions and methods of producing the same. More particularly the invention is concerned with a metallic substance, which may either be a single metal or an alloy, and containing a considerable percentage of carbon. I find that such a body has peculiar properties which render it desirable for certain technical uses.

As is well known, there is difficulty in obtaining satisfactory service from metallic contact points for opening and closing electrical circuits. The arcing or sparking between such points proves quickly destructive of the finished surfaces thereof, not only volatilizing the surfaces to cause pitting of the same, but also oxidizing these surfaces, thereby increasing the contact resistance and proportionately increasing the heating effect of the current at the contact. Through this increased resistance and heating effect further destructive pitting and oxidizing is set up. This destructive action is therefore self-perpetuating, being in the nature of a vicious circle, and limits the life of the contact points to such an extent that only a very few metals, such as platinum, and, in some special services, tungsten, are regarded as at all serviceable.

I find, however, that the commoner and less expensive metals, or alloys thereof, exhibit such properties when combined with a relatively large proportion of carbon as to arrest the destructive action referred to. The result of such a mixture of carbon with the metal is to render the metallic body practically infusible as a body, though it is quite probable that the metallic constituents of the body do, in fact, fuse. It is believed that the explanation of this property lies in the fact that the carbon present forms a

spongy or porous mass within the interstices or pores of which the metal is carried and held, whether in a solid or liquid form, the outward appearance and general physical properties of the mass being apparently unaffected by subjection to temperatures, in themselves sufficient to fuse the metal constituents. Whether this be a true explanation of the phenomenon or not, it is nevertheless certain that the apparent melting point of metals, such as nickel and nickel-iron alloys, is raised above any temperatures which I have been able to obtain by the use of an electric furnace or an oxyacetylene flame.

A further property of my metal composition which renders it peculiarly valuable as a contact metal is its resistance to oxidation under sparking or arcing conditions. I attribute this property to the fact that the arcing or sparking volatilizes the carbon present to create a reducing atmosphere which effectively prevents oxidation of the metal of the contacting face, whether this metal be, in fact, in the liquid or solid state.

To make my new metal composition by the use of this apparatus, the metal, shot nickel, is introduced into a recess or aperture in a carbon bar which is then placed in circuit with a suitable source of electric power (preferably alternating current), the current is turned on and regulated in strength until the bar reaches a temperature sufficient to melt the nickel. It should be noted that the construction of the bar is such that the metal therein serves as a conductor, this condition giving rise to a peculiar phenomenon, *i. e.*, the molten metal body lying in the bottom of the bar divides itself in the center to form separated pools which continuously reunite and again separate. As soon as the metal is thoroughly melted I add to the molten mass finely divided carbon, which I stir into the mass as it is added, preferably by the use of a carbon stirring-rod. I also find it of advantage to interrupt the current through the bar at intervals. Within a very few minutes the molten mass within the bar or crucible solidifies or sets. The process is now at an end, and the current

may be turned off, the crucible permitted to cool and the block of metal composition removed therefrom. This block may then be machined, ground or otherwise fabricated to produce contact points adapted for use in any form of make and break electrical apparatus, as, for instance, buzzers or spark-coils.

Although I prefer to stir in finely divided amorphous carbon during the heating of the metal within the crucible, this is not essential to the success of the process, since I find that the crucible walls themselves are eaten away during the process, the carbon required for the composition being thus supplied to a large extent by the crucible itself.

I find that by the process above described I am able to produce a metal composition which appears to be homogeneous throughout its mass and which upon analysis shows a percentage of carbon (by weight) of from $2\frac{1}{2}$ to 7 per cent. in the case of nickel and nickel iron alloys. The best results which I have secured have been by the use of comparatively pure shot nickel, in which I have succeeded in incorporating by this process approximately 7 per cent. of carbon. Practically all of this carbon seems to be present as graphite, there being only traces of combined carbon and amorphous carbon. It appears therefore, that not only is the carbon incorporated and homogeneously mixed in the metal, but that in the process this carbon becomes converted into graphite.

By reference to the table of specific gravities of metallic nickel and graphite it appears that 7 per cent. (by weight) of carbon would represent approximately 30 per cent. of volume or bulk of this constituent. It appears, therefore, that my new metal composition contains a sufficient percentage of graphitic carbon to distinctly differentiate it from any known metals or alloys.

As before stated, I have been able to secure the best results by the use of relatively pure nickel as a metallic constituent of my composition. I find, however, that a serviceable composition may be produced by the use of a nickel-iron alloy containing upward of 70 per cent. of

nickel and approximately $3\frac{1}{2}$ per cent. of carbon. My composition presents the general appearance of a metallic body, taking a good polish, and retaining its brightly polished surface for a considerable period of time.

By comparative tests I find that contact points made of my new metal composition, retain their efficiency for substantially the same time as do platinum points under normal loads, while under overload conditions my composition seems to be superior to platinum, being capable of carrying greater currents and withstanding the arcing set up by the passage of heavy currents with less disastrous effects than the platinum.

I claim:

1. A contact point for making and breaking electrical circuits and comprising a metal composition including upward of 70 per cent. of nickel and upward of 3 per cent. of uncombined carbon.

2. A contact point for making and breaking electrical circuits and formed of a metal composition comprising substantially pure nickel, carrying upward of 3 per cent. of uncombined carbon.

3. A cast metal contact point for making and breaking electrical circuits and comprising upward of 70 per cent. of nickel and upward of 3 per cent. of graphitic carbon.

1,229,037, Cooper (Assigned to the Electro Metals Products Company), June 5, 1917

My invention appertains to a metal alloy adapted to be used as a substitute for platinum in the electrical art, as in coils, magnetos and all vibrating instruments, and the invention consists of a composition of silver and other metals which is ductile, and malleable, and of comparatively high melting point, good electrical conductivity, great hardness, non-oxidizing, and producible at a low cost.

In all compositions of alloys known to me in which silver enters, copper is also used, but I find that this composition oxidizes very readily making it useless for electrical contact purposes, especially where the contact is exposed to high temperatures and severe usage. I also find that it is not practicable to use silver alone as it is too soft and the melting point is not high enough. However, silver is a good electrical conductor and relatively cheap as compared with platinum and when alloyed in proper proportions with other metals as hereinafter described serves as an excellent substitute for platinum. One such composition comprises silver, palladium and cobalt, in substantially the following proportions: 75 per cent. of silver, 25 per cent. of palladium, and 5 per cent. of cobalt. Platinum may be substituted for the palladium with equally good results, and nickel for the cobalt, but I prefer palladium as it may be obtained at a lower cost than platinum. I also prefer cobalt as I find it resists oxidization at a higher temperature than nickel, and it also makes a harder alloy. In this alloy I use as little of platinum or palladium as possible consistent with the durability and lasting qualities of the product, and I also find that 3 to 5 per cent. of cobalt or nickel is sufficient to furnish the hardness necessary.

What I claim is:

1. An alloy for electrical uses, comprising silver and one or more of the metals of the platinum group and a metal of the cobalt-nickel group in substantially the proportions stated.
2. An alloy for electrical uses containing silver, palladium, and a metal of the cobalt-nickel group in the proportions substantially set forth.

See U. S. Patent 1,229,960 on page 51.

1,246,552, *Becket (Assigned to Electro Metallic Company)*, Nov. 6, 1917

This invention is a new alloy containing as essential components: iron, chromium, carbon and usually silicon, and distinguished from the hertofore ferrochrome alloys, by its composition, and by the possession to a very high degree of the combined qualities of toughness, hardness, and resistance to oxidation both at low and high temperatures.

An alloy combining toughness, hardness and resistance to oxidation to a remarkable degree contains: chromium, 25 to 30 per cent.; carbon, 1.5 to 3 per cent.; silicon 0.0 to 3 per cent.; iron, 73 to 63.5 per cent., usually with traces of manganese, sulphur, phosphorus, copper, and perhaps other elements.

These alloys are very hard and tough and do not oxidize or rust in presence of water. The degree of resistance to rusting is dependent in a measure upon the silicon content of the alloy, being more strongly marked as the silicon-content is increased within the limits specified. If, however, the silicon content exceeds these limits, a tendency to brittleness is observed.

As an illustration of resistance to oxidation at high temperatures, a cast bar of alloy containing chromium, 28 per cent.; carbon, 2.7 per cent.; silicon, 0.40 per cent., the balance practically all iron, was exposed continuously at 1100° C., for two weeks to an oxidizing temperature in an electrically-heated muffle furnace without undergoing appreciable oxidation.

These alloys can be forged, machined, annealed and tempered.

They can be used for blades of steam turbines, where the highest degree of resistance to wear and oxidation are required, and for high temperature applications, especially under oxidizing conditions, as for crucibles, furnaces, etc.

I claim:

1. An alloy characterized by a high degree of hardness, toughness, and resistance to oxidation, and containing chromium 20 to 35 per cent., carbon 1.5 to 3 per cent., and silicon 0.0 to 3 per cent., the balance principally iron.

1,248,621, Cooper (Assigned to Electro Metals Products Company), Dec. 4, 1917

This invention relates to an improvement in metal alloys, the object being to provide a new and useful substitute for platinum for use in the electrical art. Platinum is used extensively for contact points in induction coils, magnetos, master vibrators, and high-frequency apparatus, and a practical commercial substitute therefor must possess substantially the same hard and wearing properties, high-melting point electrical conductivity, ductility and malleability, and be non-oxidizing. I have discovered that these requirements are met by alloying gold and silver in substantially equal proportions with a small percentage of another metal adapted to harden and raise the melting point thereof. The metals which may be added for this purpose may consist of osmium, niobium, rhodium, ruthenium, palladium, cobalt, molybdenum, tantalum, chromium, tungsten, thorium, titanium, vanadium, zirconium, or a combination of these metals. Osmium is mentioned first as is preferred as about 4 per cent. of this metal in the alloy produces a fine hard metal which does not oxidize on the surface when used as an electrical contact. Specifically stated, an alloy consisting of 4 per cent. of osmium, 48 per cent. of silver, and 48 per cent. of gold, is characterized by a high melting point, great hardness, its malleability and ductility so as to be easily worked, electrical conductivity similar to platinum, and by its low cost compared with platinum. The electrical conductivity of silver is rated at about 100, and gold 72, but I have discovered that a combination of gold and silver in approximately equal proportions produces an alloy with an elec-

trical conductivity of only about 15, or about 1 point less than platinum. Where the proportions of gold or silver vary from the foregoing by an increase or decrease of 5 per cent. or more, the alloy is not especially suited for use as a contact for a magneto as the arc at the point of contact increases to such an extent that a regular series of sparks can not be obtained.

The production of my improved alloy takes place preferably in an electric furnace and in an atmosphere free from oxidizing gases, and care must be exercised to have the metals free from impurities such as copper, silicon, etc., as these tend to oxidize, thus making the product useless for electrical purposes.

I claim:

1. A metal alloy consisting of gold, silver and osmium having a high melting point and great hardness and possessing ductile and malleable properties and an electrical conductivity similar to platinum.

2. A metal alloy consisting of gold and silver in approximately equal proportions and a relatively small percentage of osmium.

See U. S. Patent 1,248,648 on page 92.

See U. S. Patent 1,252,038 on page 306.

*1,257,272, Laird (Assigned one-half to Leo B. Lincoln),
Feb. 19, 1918*

My invention or discovery consists in the production of a new electric resistance element composed of a metal which shall have the property of being particularly low in electric conductivity, have a melting point exceeding that of pure copper, and be capable of resisting oxidation at all temperatures and under all conditions to which it needs to be subjected, while at the same time possessing characteristics permitting it to be drawn or otherwise

worked to form strips, strands or filaments; whereby highly efficient and extremely durable resistance elements result.

My invention or discovery consists simply in making an electric resistance element of an alloy of one or more of the members of the nickel group of metals (nickel, cobalt, and iron) with silicon. The addition of silicon to nickel, for example, raises the melting point of the latter and also the temperature at which oxidation will take place and at the same time lowers its electric conductivity, giving a resistance element very similar in essential characteristics to the nickel-chromium resistance material now so largely used. To make the material more ductile than it would otherwise be, cobalt may be added. While the nickel or nickel and cobalt alloys will ordinarily be preferable, iron, when alloyed with silicon will give excellent results, it being necessary of course that the iron be pure so that it will not oxidize under ordinary atmospheric conditions; pure iron being practically non-oxidizable at ordinary temperatures and the addition of the silicon raising the melting point so that oxidation at high temperatures does not become appreciable until a much higher temperature is reached than will be the case with the iron alone.

The amount of silicon employed will vary according to the service to which the resistance material is to be put. In some cases the silicon content will amount to only a few per cent., while in others it may be as high as 24 per cent. Where the alloy is of nickel, cobalt and silicon, it may be stated as a general rule that the nickel content should be at least 75 per cent. of the whole.

I claim:

An electric resistance element formed of an alloy of nickel, cobalt and silicon and containing at least 75 per cent. of nickel.

1,268,495, Sandell (Assigned to Herbert S. Mills), June 4, 1918

My invention relates to improvements in metal compositions. More particularly the invention is concerned with a metallic alloy comprising nickel and tungsten and containing a considerable percentage of carbon. I find that such a body has peculiar properties which render it specially desirable for use as a contact point for making and breaking electrical circuits.

In order to prepare my new metallic substance the apparatus and procedure fully described in my prior patent No. 1,223,002, may conveniently be employed. In brief, the apparatus in question consists of a carbon block having a trough, or hollow, in its upper surface, which serves as the crucible for the production of the alloy. This crucible is heated by internally developed heat generated by the passage through its walls of an electrical current, which is preferably an alternating current.

The metals to be alloyed, *i. e.*, nickel and tungsten, each of which should be in a relatively pure state for the best results, are introduced into the crucible and the latter raised to such a temperature as to cause them to fuse. Powdered amorphous carbon, or powdered graphitic carbon is then introduced into the fused mass, the mass being preferably stirred with a carbon stirring-rod. I also find it of advantage to interrupt the current through the crucible at intervals. Within a very few minutes the molten mass within the crucible solidifies or sets. The process is now at an end and the current may be turned off, the crucible permitted to cool and the block of metal composition removed therefrom. This block may then be machined, ground or otherwise fabricated to produce contact points, or other structural elements.

Although I prefer to stir in finely divided amorphous carbon, or finely divided graphitic carbon, during the heating of the metal within the crucible, this is not essential to the success of the process, since I find that the crucible

walls themselves are eaten away during the process, the carbon required for the composition being thus supplied to a large extent by the crucible itself.

I find that by the process above described, I am able to produce a metal composition which is substantially homogeneous throughout its mass and which upon analysis shows a percentage of carbon (by weight) of from $2\frac{1}{2}$ to 7 per cent. For the manufacture of contact points I prefer to use for my metal composition substantially pure nickel and tungsten in about the proportions of 4 parts of nickel to 1 part of tungsten. The metal composition having these constituents I find to be superior to the composition described in my prior application above referred to, in that it is considerably harder and has a longer life when used as a contact point and subjected to the arcing and sparking which is there met with.

My new metal composition herein described possesses the peculiarities and advantages of the composition described in my prior application above referred to, and in addition is superior to the last-named composition in the respects pointed out.

I claim:

1. A metal composition comprising substantially an alloy of more than 50 per cent. of nickel and less than 50 per cent. of tungsten carrying upward of 3 per cent. of uncombined carbon.

2. A contact point for making and breaking electrical circuits and comprising substantially an alloy of more than 50 per cent. of nickel and less than 50 per cent. of tungsten carrying upward of 3 per cent. of uncombined carbon.

3. A metal composition comprising substantially an alloy of 4 parts of nickel and 1 part of tungsten carrying upward of 3 per cent. of uncombined carbon.

1,274,250, Driver, July 30, 1918

My invention relates to a new and improved alloy for resistance elements, etc., and has for its object to produce

an alloy which has a high specific electrical resistance together with a prolonged life under conditions of high temperature, so as to render it suitable for the making of resistance elements.

My invention is based on the discovery that when titanium in substantial amounts is added to other metals, such as nickel, iron, copper, etc., or alloys of metals, it causes a marked increase in specific electrical resistance of the alloy so formed and produces an alloy which is extremely resistant to oxidization, especially at high temperatures. From numerous experiments I have found that titanium is more powerful in these respects than chromium, and that titanium and chromium when simultaneously used as alloys with other metals, produce highly desirable results. I have also discovered that relatively large quantities of titanium can be used in alloys without making them too hard or too brittle to allow rolling and drawing.

For the purpose of illustration I give below a list of alloys made according to my invention, together with the specific electrical resistance in michroms per cubic centimeter of said alloys respectively.

	Nickel	Chromium	Titanium	Iron	Man- ganese	Specific Resistance
No. 1.....	75%	....	6%	19%	....	77
No. 2.....	68	15%	4	11	2%	117
No. 3.....	65	....	8	27	....	96
No. 4.....	65	....	6	19	10	106
No. 5.....	60	12	1	24	3	112
No. 6.....	60	12	6	19	3	125
No. 7.....	40	15	6	39	....	112
No. 8.....	30	10	6	54	....	117
No. 9.....	30	....	6	64	....	100

Copper

No. 10.....	80	10%	3	....	7	48
No. 11.....	75	....	8	....	17	57
No. 12.....	45	45	3	....	7	77
No. 13.....	94	....	5	1	....	32

The percentages in the above table, while not exact, are approximately correct. The presence of titanium in each of these alloys increases the life at high temperatures of the metal or alloy to which it is added.

The qualities imparted by the addition of titanium are particularly valuable in connection with resistance elements used in electrical apparatus such as heaters, toasters and cooking appliances, where the resistance elements are subjected to high temperatures by the passage of electric currents through them. These electrical resistance elements may be of any ordinary form, such for instance as open helices or spirals. The form of the resistance element constitutes no part of my invention.

I have discovered that titanium hardens the metals or alloys to which it is added so that the quantity of titanium that can be used is limited when it is necessary to retain such malleability and ductility as will permit the rolling or drawing of the alloy. The alloys above referred to are all sufficiently malleable and ductile so as to permit such rolling and drawing.

The melting to form the alloy can be carried on in any approved manner, special care being exercised to prevent the introduction of carbon, either through the metals that are used or through contamination from the vessel in which the melting is done. Pure titanium is not commercially obtainable so far as I am aware. My experiments have been carried out with nickel-titanium and ferro-titanium. Even if pure titanium were available its melting point is so high that it would not be desirable to form an alloy directly from it. An alloy of one of the metals which is to form a substantial part of the final alloy should be used as a carrier for the titanium for the final melting, which is as low as possible in contained titanium as is compatible with the amount of titanium to be introduced, thereby providing a low melting point and making easier its incorporation into the final alloy. Owing to the relatively low specific gravity of titanium, there is a tendency of the titanium carrying alloy to rise to the surface of the melted

bath, and care should be used to make sure that it is entirely submerged so that it will be properly incorporated into the bath.

Quantities of titanium as low as 1 per cent. are effective in increasing the electrical resistance of alloy containing it and in protecting the alloy against oxidization at high temperatures. This effect increases with the percentage of titanium added. The only use of titanium in connection with melted metal baths of which I am aware, has been for the purpose of cleansing steel by removing impurities therefrom, and in this connection only small fractions of 1 per cent. have been found necessary or desirable. So far as I am aware, the quantity so used has been limited to less than $\frac{1}{2}$ of 1 per cent., so that in the finished product there remains no substantial amount of titanium and no amount which affects in any substantial degree the specific electrical resistance, life or hardness of the ultimate product.

I claim:

1. A ductile and malleable alloy of high specific electrical resistance containing as a constituent at least 1 per cent. of titanium and over 20 per cent. of nickel, substantially as described.

2. A ductile and malleable alloy containing as a constituent at least 1 per cent. of titanium and over 20 per cent. of nickel, substantially as described.

3. A ductile and malleable alloy containing as constituents over 20 per cent. of nickel and at least 1 per cent. of titanium, substantially as described.

BRITISH PATENTS

CLASS 3-A

16,324 of 1884, Lecomber

Non-oxidizable or difficultly oxidizable hard alloys, consist of 9 parts of gold, 1 of silver and 14 of copper, or 3 parts of gold, three of iridium, and 4 of platinum. Nickel-cobalt, chromium, or palladium may be added. These alloys are very ductile.

6,367 of 1886, Newton

This patent describes white, hard, non-oxidizable alloys, having a small coefficient of expansion when heated. The alloys consist essentially of palladium, 72 per cent.; rhodium, 1 per cent.; platinum, 5 per cent.; gold, 1.5 per cent.; silver, 6.5 per cent.; copper, 18.5 per cent. A number of other formulas embodying the use of nickel and steel, are given. These alloys are very ductile. Descriptions are given of the methods of working up the alloys. Several alloys without platinum are mentioned as, palladium, 70 per cent.; silver, 4 per cent.; copper, 25 per cent.; nickel, 1 per cent., or palladium, 65 per cent.; gold, 1 per cent.; silver, 5 per cent.; nickel, 4 per cent.; copper, 25 per cent.

11,940 of 1888, Ostermann

A hard, ductile, non-oxidizable alloy consists of the following metals: gold, 30 to 40 parts; palladium, 30 to 40; rhodium, 1/10 to 5; copper, 10 to 20; manganese 1/10 to 5; silver, 1/10 to 5, and platinum 1/10 to 5.

11,941 of 1888, Ostermann

A hard, very ductile, non-oxidizable alloy, consists of the following metals: gold, 30 to 40 parts; palladium, 30 to 40; copper, 40 to 20; silver, 1/10 to 5; cobalt, 1/10 to 5; wolfram, 1/10 to 5; rhodium, 1/10 to 5, and platinum 1/10 to 5. The copper and wolfram are first melted, covered with powdered charcoal and the remaining ingredients are then added.

14,762 of 1888, Perret

Ductile, non-oxidizable alloys consist of platinum and nickel, or iridio-platinum and nickel, to which a small quantity of silver is added, if a white alloy is required.

See British Patent 9,050 of 1890, page 308.

See British Patent 18,343 of 1890, page 308.

19,770 of 1898, Boult

Wires composed of alloys of platinum, iridium, rhodium, and palladium, are used in the construction of mantles for incandescent gas burners for lighting and heating. Where the gas burned has a pressure not exceeding 100 millimeters, the warp wires may consist of 88 per cent. of platinum; 10 per cent. of iridium, and 2 per cent. rhodium, and the wires may consist of 9 per cent. of platinum; 5 per cent. of iridium; 2 per cent. of rhodium, and 3 per cent. of palladium. Where the gas is under pressure, the wires are composed of 85 per cent. of platinum; 12 per cent. of iridium, and 3 per cent. of rhodium.

See British Patent 21,170 of 1900, page 309.

2,129 of 1906, Boult

This corresponds to U. S. Patent No. 873,745 on page 12.

8,359 of 1907, Boult

This corresponds to U. S. Patent 859,608 on page 159.

26,940 of 1907, British Thomson-Houston Co.

A refractory alloy suitable for use in electric resistances, contains nickel, iron, chromium and manganese, the nickel being in excess of the other constituents, traces of silicon, carbon, and phosphorus are also present. In making the alloy, nickel, high in carbon, is first melted in a clay-lined crucible with iron oxide as a reducing agent, silica and cryolite being used as a flux. When the carbon is eliminated the iron, chromium, and manganese are added separately, and the mixture is poured off before the manganese attacks the lining.

This corresponds to U. S. Patent 926,980, page 163.

See British Patent 26,380 of 1908, page 62.

26,826 of 1908, British Thomson-Houston Co.

This corresponds to U. S. Patent 926,980, page 163.

22,833 of 1909, Fleitman

The incandescent mantle holders, protectors and the like parts of incandescent gas lamps of the ordinary upright and of the inverted type are exposed to very high temperatures while the lamps are lit so that the choice of material for these parts of the lamps is very restricted.

Heretofore for the incandescent body supports of upright incandescent lamps and for the supporting rings of inverted incandescent lamps, magnesium and similar substances have usually been employed. These supports and rings have, however, very little strength and they are cracked very easily by the heat or they break in pieces when they are touched in any but the most careful way.

In the manufacture of protectors as employed in lamps with inverted incandescent gas burners in railway carriages, for example, it is quite out of the question to employ magnesium, so that these protectors have hereto-

fore usually been stamped out of nickel, tin, or iron. Such protectors, however, under the influence of the high temperatures quickly scale away. They become burnt through in a short time, or become very brittle and soft so that they break into pieces on being touched, no matter how lightly, and fall into bits even when gently shaken.

The subject-matter of the present invention is the preparation of these lamp parts from a metal alloy which is thoroughly capable of withstanding the heat developed in an incandescent gas lamp and which permanently retains the strength peculiar to the metal, and it is not inclined to scale away. The metal alloy in question consists of a mixture of nickel and chromium which may contain up to 20 per cent. of chromium. This chromium alloy, which is able, without injury, to contain additions of iron, manganese, carbon and other impurities, can be produced in the form of wire ribbon or sheet and can be worked by being rolled, hammered and pressed and the like and is similar to platinum in appearance. It has a high melting point with great strength and neither becomes soft in hot flames nor brittle, nor does it scale away or form laminae.

Similar alloys have already been tried for the manufacture of electric resistances, this having been chiefly on account of their high electric specific resistance. Now, although in this case it was recognized that the resistances by these alloys was materially higher than that of iron as regards the actions of atmospheric oxygen and at fairly high temperatures, yet the great lack of sensibility of these alloys to the permanent influence of incandescent gases remained unknown and has not been applied as in the case of the present invention since the behavior of the alloys in the case of the comparatively low temperatures of electric resistance which only now and then attain for a short time a red hot temperature, did not give any guarantee that such alloys would likewise be able permanently to stand the much higher temperatures maintained continuously for hours and days of incandescent gas at about from 1000° to 2000° C.

Consequently exhaustive experiments were necessary in order to ascertain that such alloys are particularly appropriate for the manufacture of highly refractory lamp parts.

6,240 of 1910, Krupp Akt. Ges.

An alloy for the manufacture of safe or steel chamber walls consists of steel to which is added such an amount of chromium, preferably not exceeding 40 per cent., that the alloy cannot be melted through by an oxyhydrogen, acetylene or the blowpipe flame. The amount of chromium present depends upon the amount of carbon in the alloy. The alloys may also contain tungsten or silicon.

This corresponds to U. S. Patent 1,026,461, page 249.

14,743 of 1910, British Thomson-Houston Co.

An electric resistance alloy containing principally nickel, iron, and chromium as described in Specification No. 26,940/07 has a carbon content of from 0.1 to 0.4 per cent.

See British Patent 16,177 of 1910 on page 105.

See No. 29,723 of 1910 (corresponds to Reissue No. 13,961 on page 274).

10,657 of 1912, Gualtierotti

An alloy consists of silicon with not more than 18 per cent. of a metal, such as iron, nickel, copper, or magnesium, and is cast in a mould which has movable parts to allow free contraction of the alloy when solidifying. The castings may be in the form of rings, spirals or bars for use in rheostats, or as brushes for electric motors, or for singeing threads and cotton fabrics electrically.

28,953 of 1912, Marino

Cobalt silver alloys may contain 90 per cent. of cobalt and have a permanent lustre equal to that of silver. These

alloys and also nickel-platinum and lead-iron alloys may be deposited electrolytically.

It is also stated that an alloy of nickel and platinum will not oxidize or become dull.

13,413 of 1913, Paset

This invention relates to the manufacture of articles having parts of iron which are permanently or temporarily subjected to a high temperature (about 700° to 1000° C.), and the object of the invention is to protect the iron parts against the injurious action of the oxidation, which takes place at such temperatures in the presence of air.

For the manufacture of the iron parts, iron alloys are suitable which contain from 15 per cent. to 25 per cent. of chromium. In addition to chromium, the alloys may contain nickel. The effect of the nickel in such case is that the necessary minimum quantity of chromium required is smaller. Thus, for example, if the alloy contains 30 per cent. of nickel, 10 per cent. of chromium is sufficient, and if the alloy contains 36 per cent. of nickel, 5 per cent. of chromium is sufficient. The nickel therefore possesses the property of being able to replace a portion of the chromium in its action on the power of resisting the formation of oxide.

As a sphere of application of the invention there may be mentioned, for example, salt bath vessels for hardening furnaces, protection pipes on pyrometers, also articles with iron parts fused into glass, as the iron parts even when fused into the glass are subjected to high temperatures and therefore to oxidation.

In the last mentioned case it is important that the alloys employed for the manufacture of the iron parts, possess the same coefficient of expansion as the glass. Such alloys can be obtained if there be added about 36 per cent. of nickel to an iron-chromium alloy, which, according to the desired coefficient of expansion (which varies somewhat for the different kinds of glass), contains from about

5 per cent. to 15 per cent. of chromium. As an example, it may be mentioned, that within the temperature limit of from 15° to 100° C., an alloy containing 36 per cent. of nickel and 8 per cent. of chromium has a coefficient of expansion of 6.5 (10^{-6}) and an alloy containing 36 per cent. of nickel and 12 per cent. of chromium has a coefficient of expansion of 8.8 (10^{-6}).

19,021 of 1913, British Thomson-Houston Co.

A composite metal for making crucibles consists of an alloy of nickel and copper in which the nickel predominates, united to one or both sides of a metal consisting mainly of iron by copper. The copper-nickel alloy which may be that known as "Monel" metal is connected to the iron or steel by melting intermediate layers of copper in a reducing or inert atmosphere which may be provided by hydrogen or by an electric vacuum furnace. A suitable sheet metal contains about 13 per cent. of manganese, or an alloy consisting of 77 per cent. of iron, 17 per cent. of nickel, 4 per cent. of chromium, and 2 per cent. of manganese may be used.

8,270 of 1914, Joyce

This invention relates to alloys of copper, nickel, and aluminium or of copper, nickel, aluminium and steel. Alloys of these metals have been proposed for various purposes. For example, an alloy intended for hardening aluminium to which it was added in a fused state consisted of 2 to 6 parts by weight of copper, 1 to 3 nickel, 1 to 2 fine cast steel and 1 aluminium. Another alloy contained 89 to 98 per cent. copper and 11 to 2 per cent. nickel-aluminium, and in another the proportions by weight were 150 to 250 nickel, 850 to 750 copper, and $1\frac{1}{2}$ to 1 aluminium.

Now, the object of this invention is to produce an improved alloy which is specially suitable for mounting diamonds or for golf clubs and the like, and will not rust or tarnish when exposed to the air or moisture.

According to this invention the copper is alloyed with nickel, aluminium and steel or with nickel and aluminium only, substantially in the following proportions, three examples being given below, of copper-nickel-steel-aluminium alloys in which the proportions are varied to some extent to give different degrees of ductility and tensile strength.

	I.	II.	III
Copper	27½%	35%	40%
Nickel	65	50	45
Steel	5	10	10
Aluminium .	2½	5	5

I will now describe one method of preparing the improved alloy, although I would have it understood that I do not confine myself to this method to the exclusion of other methods within the scope of my invention.

The copper is first reduced to melting point by means of any melting process and the nickel is then added to it until the desired proportion of copper and nickel are obtained. The steel is now added gradually and when these three metals have become alloyed, the aluminium is added, when a complete alloying of the metals takes place almost immediately, and the metal can be poured, giving a clean casting.

The alloys can also be prepared in other ways to suit the fusing points of the constituent metals or the proportions employed in accordance with the methods easily followed in preparing alloys, for example, the least fusible metals may be melted first and the more fusible metals added afterwards or the different metals may be melted separately in different crucibles

Aluminium, copper and nickel in the following proportions also yield a similar alloy to those described, that is in different crucibles.

Copper	80.5
Nickel	17.06
Aluminium	2.44

These alloys are non-corrodible and do not char after subjection to great heat, and take a high polish. They are more especially useful for mounting diamonds for use in industrial purposes such as emery trimming, boring crowns, diamond dies and the like, on account of their great tenacity and tensile strength; the high coefficient of contraction in cooling serving to hold the diamond very firmly.

They are also very suitable for golf clubs and for all purposes calling for metals of high tensile strength combined with ductility and capacity for resisting oxidation, under any usual condition generally producing those defects and deteriorations.

106,397, Electrical Contacts, Rignon, G. A., 1917

The contacts of magnetos are formed of tungsten, molybdenum, or other metal of the iron group electrothermally welded to a suitable support and coated on its surfaces except at the contact points with a metal of high conductivity, such as copper or silver.

U. S. PATENTS

CLASS 3-B.

7,008, Spratt, Jan. 8, 1850

This invention relates to points for lightning conductors.

The nature of my invention consists of forming an alloy of the metals, etc., in the following proportion, namely: I fuse together 60 pounds of English block-tin, 5 pounds of oxide of tin, 14 pounds of antimony, 14 ounces of bismuth, 8 pounds of refined silver, 2 ounces of platinum, and as much silex as the metals will take up. I arrange the metals, etc., in the melting-vessels as follows: I put the silex, when pulverized and mixed with a little potash to serve as a flux, at the bottom of the crucible, on the top of which I pour on the oxide of tin, to which I add the block-tin and bismuth. When any of the above assume a fluid state I add the antimony, and, lastly, when it has got its proper heat, I add the silver and platinum, the whole of which forms the said alloy for lightning-rod points.

250,326, De Villiers, Nov. 29, 1881

This relates to an inoxidizable alloy. The proportions in the alloy may be somewhat varied according to the purpose in view (provided the desired properties are obtained), but the following proportions are preferred: (1) 80 parts by weight of tin, 18 of lead, and 2 of silver, or (2), 90 of tin, 9 of lead, and 1 of silver. The tin is first melted; while it is thoroughly fused, the lead is added in a granulated state, and the mixture is slowly stirred, preferably

with a dry fir-wood rod. The silver, separately melted, is then likewise mixed with the compound. The fire under the melting pot is now quickly increased till the surface of the metal has a yellowish tinge. It is then rapidly stirred and run into ingot moulds. Stress is laid on the procedure adopted.

The alloy produced will strongly adhere to iron and steel, and will impregnate them when they are prepared to receive it by a treatment described, whereby they are perforated with almost infinitesimally small holes. Of the different metals employed, the tin imparts pliability to the alloy, the silver renders it hard, lustrous, andinoxidizable, and the lead increases its fluidity and power of percolation into the interstices and pores of iron and steel.

The inoxidizable alloy may be applied to other metals and alloys capable of resisting the heat required, and sometimes it is made of tin and lead alone. The treatment of knife blades is described.

367,158, Paillard, July 26, 1887

One object of my invention is to produce an alloy which shall be unoxidizable and non-magnetic.

My alloy is composed of palladium, copper, and iron, in about the following proportions, viz.: Palladium, 60 to 75 parts; copper, 15 to 25 parts; iron, 1 to 5 parts; but said proportions or percentages may be somewhat varied without changing or affecting the essential characteristics or properties of the alloy to any appreciable extent.

367,159, Paillard, July 26, 1887

My invention relates to a metallic alloy, which will be unoxidizable and only slightly magnetic and dilatable.

This alloy is composed of the following metals, in about the proportions stated, viz.: palladium, 50 to 75 parts; copper, 20 to 30 parts; iron, 5 to 20 parts.

367,160, Paillard, July 26, 1887

My invention relates to a metallic alloy which will be non-magnetic, unoxidizable, and practically non-dilatable.

This alloy is composed of the following named metals, combined in about the following proportions, viz.: palladium, 65 to 75 parts; copper, 15 to 25 parts; nickel, 1 to 5 parts; gold, 1 to $2\frac{1}{2}$ parts; platinum, $\frac{1}{2}$ to 2 parts; silver, 3 to 10 parts; steel, 1 to 5 parts.

367,161, Paillard, July 26, 1887

The object of my invention is to produce an alloy which will be unoxidizable and non-magnetic.

This alloy is composed of the following metals, in about the proportions named, viz.: palladium, 45 to 50 parts; silver, 20 to 25 parts; copper, 15 to 25 parts; gold, 2 to 5 parts; platinum, 2 to 5 parts; nickel, 2 to 5 parts; steel, 2 to 5 parts.

381,719, Ostermann & La Croix, Apr. 24, 1888

A non-oxidizing alloy is made of the following:

Gold	30 to 40 parts
Palladium	25 to 35 parts
Copper	30 to 40 parts
Silver	$\frac{1}{10}$ to 1 part
Tungsten	1 to 5 parts
Cobalt	$\frac{1}{2}$ to $2\frac{1}{2}$ parts

The tungsten is first melted with the copper and this combination is thus melted with the other metals.

This alloy has the same hardness and elasticity as steel.

384,709, Paillard, June 19, 1888

The object of my invention is to produce a non-magnetic inoxidizable metallic alloy which shall possess the qualities of steel.

The alloy which I have now invented is composed of the following metals, in about the proportions specified, viz.: palladium, 25 to 45 parts; copper, 30 to 60 parts; silver, 5 to 20 parts; steel, 2 to 5 parts.

385,945, *O'Hara et al.*, July 10, 1888

A resilient, unoxidizable, and non-magnetic alloy is made of 80 parts of gold, $13\frac{1}{2}$ parts of nickel, $6\frac{2}{3}$ parts of platinum.

385,946, *O'Hara*, July 10, 1888

Our invention has for its object to provide an alloy or compound metal which shall be inoxidizable.

Our improved alloy consists of a compound of platinum, copper, nickel, and gold in about the following proportions: platinum, from 75 to 90 parts; copper, 24 parts; nickel, 8 parts; gold, 6 parts.

385,947, *O'Hara et al.*, July 10, 1888

Our invention has for its object to provide an alloy or compound metal which shall be inoxidizable.

Our improved alloy consists of a compound of platinum, copper, nickel, and gold in about the following proportions: platinum, from 30 to 50 parts; copper, 30 parts; nickel, 10 parts; gold, 10 parts.

385,948. *O'Hara*, July 10, 1888

Our invention has for its object to provide an alloy or compound metal which shall be inoxidizable.

Our improved alloy consists of a compound of platinum, nickel, and copper in about the following proportions, viz.: platinum, 50 to 60 parts; nickel, 30 parts; copper, 20 parts.

385,949, *O'Hara et al.*, July 10, 1888

Our invention has for its object to provide an alloy or compound metal which shall be inoxidizable.

Our improved alloy consists of a compound of platinum, copper, nickel, and gold in about the following proportions: platinum, from 60 to 75 parts; copper, 24 parts; nickel, 8 parts; gold, 8 parts.

385,950, O'Hara, July 10, 1888

Our invention has for its object to provide an alloy which shall be inoxidizable.

Our improved alloy consists of a compound of platinum, copper, nickel, and gold in about the following proportions: platinum, 60 parts; copper, 24 parts; nickel, 10 parts; gold, from 5 to 20 parts.

385,951, O'Hara, July 10, 1888

Our invention has for its object to provide an alloy or compound metal which shall be inoxidizable.

Our improved alloy consists in a compound of platinum, copper, nickel, and gold in about the following proportions, viz.: platinum, 62 parts; copper, 24 parts; nickel, 8 parts; gold, 6 parts.

385,952, O'Hara et al., July 10, 1888

Our invention has for its object to provide an alloy or compound metal which shall be practically inoxidizable.

Our improved alloy consists of a compound of platinum, nickel, copper, and gold in about the following proportions: platinum, 50 parts; nickel, 20 parts; copper, from 5 to 40 parts; gold, 10 parts.

385,953, O'Hara et al., July 10, 1888

Our invention has for its object to provide an alloy or compound metal which shall be inoxidizable.

Our improved alloy consists of a compound of platinum, copper, nickel, and gold in about the following proportions: platinum, 60 parts; copper, 22 parts; nickel, from 5 to 40 parts; gold, 8 parts.

385,954, *O'Hara et al.*, July 10, 1888

Our invention has for its object to provide an alloy or compound metal which shall be inoxidizable.

Our improved alloy consists of a compound of platinum, copper, nickel, and gold in about the following proportions: platinum, 75 parts; copper, 10 parts; nickel, 10 parts; gold, from 10 to 40 parts.

385,955, *O'Hara et al.*, July 10, 1888

Our invention has for its object to provide an alloy or compound metal which shall be inoxidizable.

Our improved alloy consists of a compound of silver, zinc, tin, lead, arsenic, and cadmium in about the following proportions, viz.: silver, 60 parts; zinc, 35 to 60 parts; tin, $4\frac{1}{2}$ parts; lead, $3\frac{1}{2}$ parts; arsenic, $\frac{1}{2}$ part; cadmium, $1\frac{1}{2}$ parts.

388,145, *Ostermann & LaCroix*, Aug. 21, 1888

Our invention consists of a new metallic alloy intended to be used in place of steel, especially in manufacturing such parts of watches or chronometers which are liable to alter the good acting of the watch or chronometer when they get magnetized or oxidized.

Our metallic alloy is composed of gold, palladium, rhodium, copper, nickel, manganese, silver, and platine. Those metals are suitably combined together in the following proportions: 30 to 45 parts of gold; 20 to 30 parts of palladium; 0.1 to 5 parts of rhodium; 10 to 20 parts of copper; 1 to 10 parts of nickel; 0.1 to 5 parts of manganese; 0.1 to 5 parts of silver, and 0.1 to 2.5 parts of platine.

388,146, *Ostermann & LaCroix*, Aug. 21, 1888

Our invention consists of a new metallic alloy intended to be used in place of steel, especially in manufacturing such parts of watches or chronometers which are liable to alter the good acting of the watch or chronometer when

they get magnetized or oxidized, especially in manufacturing balance-wheels and spiral springs for watch-escape-ments.

Our metallic alloy is composed of gold, palladium, rhodium, copper, manganese, silver, and platine. Those metals are suitably combined together in the following proportions: gold, 30 to 40 parts; palladium, 30 to 40 parts; rhodium, 0.1 to 5 parts; copper, 10 to 20 parts; manganese, 0.1 to 5 parts; silver, 0.1 to 5 parts; and platine, 0.1 to 5 parts.

408,130, Ostermann & LaCroix, July 30, 1889

The invention is a new metallic alloy to be used in place of iron or steel in the manufacture of articles which must be inoxidizable and not influenced by magnetism.

The said alloy is composed of nickel, chromium, platinum, copper, lead, zinc, and tin. These metals are preferably combined in the proportions set forth below and in the following manner: An alloy is first made of nickel and chromium by melting the two metals together. Another alloy is made of platinum, copper, lead, zinc, and tin, and then the two alloys are melted together. The metals employed are in the following proportions: 1 to 80 per cent. of nickel; 1 to 30 per cent. of chromium; 0.1 to 20 per cent. of platinum; 0.1 to 50 per cent. of copper; 0.05 to 15 per cent. of zinc; 0.1 to 1.5 per cent. of lead; 0.05 to 0.5 per cent. of tin.

420,598, Golay, Feb. 4, 1890

My composition is non-magnetic and inoxidizable.

The alloy is composed of about 40 per cent. platinum, about 35 per cent. copper, and of about 25 per cent. nickel, and this is preferably used with an external band of an alloy composed of about 55 per cent. silver, about 35 per cent. zinc, and of about 10 per cent. copper.

467,329, Miles, Jan. 19, 1892

My invention relates to an alloy which is a new and useful alloy that is entirely non-oxidizing and will not rust.

The same consists in the combination of the following named metals, to wit: osmium, iron or steel, tungsten (metallic), manganese, nickel and aluminium.

The proportions in which the above-named metals are combined in manufacturing the desired articles are entirely optional, and depends wholly upon the nature of the article to be produced in order to accommodate the strength of the alloy to the qualities of said article.

485,423, O'Neill, Nov. 1, 1892

This invention has relation to an improvement in metallic alloys; and the principal object of the invention is to produce an alloy of exceedingly-high electrical resistance, which, being manufactured in wire or strip form, will present a conductor which by virtue of this high resistance will evolve from a given electrical current a greater amount of heat than, it is believed, has yet been obtained by means of the metallic conductor or wires heretofore employed. It is also designed to produce in this alloy a material which will resist oxidizing influences, and which, while it has great tensile strength, will possess anti-fusion properties, so as to withstand intense heat.

This alloy is principally designed for use in the form of wire in the construction of electrical-heating apparatus, rheostats, and other electrical appliances of character requiring a conductor of this nature.

For this alloy I take 8 parts of a composition consisting of 92 per cent. of copper, 7 per cent. of tin, and 1 per cent. of diatomaceous earth or silicon. To these 8 parts of the composition described I add 6 parts of nickel and 3 parts of zinc. These materials or ingredients are reduced in a crucible and cast in a bar, which may be by ordinary means drawn into wire form, this being the principal form in which this alloy will be manufactured.

For the purposes of producing in the alloy greater ductility without lessening the resistance I may sometimes add to the alloy a little platinum—say about 1 per cent.

533,970, Susini et al., Feb. 12, 1895

The object of the invention is the production of a quaternary alloy constituting, so to speak, a new metal which has absolutely new physical and chemical properties.

This alloy is mainly characterized by very great mechanical resistance to tension, shock and compression; also by its beautiful golden color and by its superior inoxidizability. It moreover, is capable of being rolled with the utmost facility, either cold or hot, to all thicknesses. It may be moulded with ease to great thinness without presenting blowholes in sand, metal or other moulds. Having great resistance and a high ductility it may be extended to capillary diameters. It may be forged like iron with facility and may therefore be adapted to the manufacture of most delicate and complicated objects. Its malleability, ductility and elasticity are those of metals possessing these qualities in the highest degree. It may be drawn out in tubes of all diameters and thicknesses, either hot or cold, and may be stamped or embossed, for any mechanical or artistic purpose like gold, silver, copper, brass, etc. According to its degree of hammer hardening or annealing it may be elongated to from 3 to 40 per cent.

This new quaternary alloy possesses elasticity and resistance equal to those of the best steels, together with ductility, malleability elongation equal to those of copper, brass, gold and silver. Owing to these properties it may with advantage take the place of all the metals usually employed in most of the industrial applications beginning with steel and iron, including copper, brass, bronze and including also most precious metals and their alloys.

The new alloy is composed of copper, aluminium, tungsten and phosphorous. The composition being always the same it may, nevertheless, vary according to the quantities

of the several component bodies, such variations depending upon the degree of resistance to elongation, ductility and malleability sought to be obtained to answer the purposes for which it is intended and which allows of the production of metals according to a scale of numbers corresponding to the most varied uses.

We have found that by varying the composition, quantitatively, the following eight fundamental types may be obtained :

First.—Copper, 90 per cent.; aluminium, 5 per cent.; tungsten, $4\frac{1}{2}$ per cent.; phosphorous, $\frac{1}{2}$ per cent.

Second.—Copper, 89 per cent.; aluminium, 6 per cent.; tungsten, $4\frac{1}{2}$ per cent.; phosphorous, $\frac{1}{2}$ per cent.

Third.—Copper, 88 per cent.; aluminium, 7 per cent.; tungsten, $4\frac{1}{2}$ per cent.; phosphorous, $\frac{1}{2}$ per cent.

Fourth.—Copper, 87 per cent.; aluminium, 8 per cent.; tungsten, $4\frac{1}{2}$ per cent.; phosphorous, $\frac{1}{2}$ per cent.

Fifth.—Copper, 86 per cent.; aluminium, 8 per cent.; tungsten, $5\frac{1}{2}$ per cent.; phosphorous, $\frac{1}{2}$ per cent.

Sixth.—Copper, 85 per cent.; aluminium, 9 per cent.; tungsten, $5\frac{1}{2}$ per cent.; phosphorous, $\frac{1}{2}$ per cent.

Seventh.—Copper, 83 per cent.; aluminium, 10 per cent.; tungsten, $6\frac{1}{2}$ per cent.; phosphorous, $\frac{1}{2}$ per cent.

Eighth.—Copper, 95 per cent.; aluminium, 3 per cent.; tungsten, $1\frac{1}{2}$ per cent.; phosphorous $\frac{1}{2}$ per cent.

We proceed in the manner as follows: First, the operation consists in combining the tungsten with copper. To effect this without employing pure metallic tungsten, which is very costly and difficult to obtain, we resort to the direct reduction of tungstiferous ore by electrolytic copper, chemically pure, in the presence of carbon (charcoal) in a brasque crucible highly treated in a crucible furnace. We then obtain a metallic mass containing 50 per cent. of copper and 50 per cent. of tungsten, alloyed with traces of other metals which happened to be in the ore, which, however, do not injure the composition. Second, the alloy thus

obtained is put in a crucible with a quantity of copper necessary to produce with it one of the eight above mentioned compositions. Third, when the compound is melted at white-red heat and intimately mixed, we add the quantity of aluminium indicated in the formula. Fourth, the aluminium melts immediately. The mass is then given another good stirring and finally to it is added one-half of a per centum of phosphorous which refines it, frees it from all impurities which will gather on the surface of the bath, whence it may be removed and poured at cherry heat into sand or other suitable ingot moulds. The unmoulding may be effected immediately and the bars, plates, or other form of castings are ready at once for further manipulations of rolling, drawing, forging, etc.

The new quaternary alloy herein described, composed of copper, aluminium, tungsten and phosphorous, and having the characteristics referred to, is known as "cyrnium."

See U. S. Patent 573,615, page 74.

577,851, Hadfield, March 2, 1897

This invention relates to a new alloy of iron.

The constituents of the alloy are iron, manganese, nickel, and carbon, the quaternary alloy formed being very different in its characteristics from the ternary alloy of iron, carbon, and manganese.

In practising my invention I have found the following proportions to be productive of good results when malleableness is desired: To 79 pounds of decarburized and desiliconized iron I add 6 pounds of 80 per cent. ferro-manganese and 15 pounds of nickel, the resulting steel or malleable alloy of iron containing about 0.65 per cent. carbon, 5 per cent. manganese, and 14 per cent. nickel.

A ternary alloy of iron, carbon up to 1.5 per cent. and from 3 to 8 per cent. of manganese, is slightly magnetic, hard, has high thermal and electrical resistance, but it

cannot be machined, and its field of usefulness is thereby exceedingly limited.

The quaternary alloy embodying my invention possesses wholly new properties, as the addition of the nickel actually increases the thermal and electrical resistance and renders it capable of being machined, while making it practically non-magnetic. It possesses a high elastic limit, much higher than mild steel. Its hardness varies according to the percentages of the constituents, but the alloy containing about 5 per cent. manganese and 14 per cent. nickel can be readily machined.

692,198, Gesner, Jan. 28, 1902

An alloy of iron and hydrogen is disclosed in U. S. Patents Nos. 604,580, 642,320 and 640,775.

To give this alloy the strength and hardness of cast iron, 20 parts of copper are added to 79.89 parts of iron and 0.11 parts of hydrogen.

Tin may sometimes be added, beginning at 2 per cent.

This alloy has very high resisting power to oxidation by the atmosphere, moisture, etc.

*952,290, Whitney (Assigned to General Electric Company),
March 15, 1910*

My invention comprises an alloy of iron and boron, which may be termed a boron-steel, possessing electrical properties, especially adapting it for use in electrical apparatus, such as transformer plates.

It is well-known in the electrical art when iron is traversed by a varying magnetic field there occur certain losses of energy, which reappear as heat. These losses, known as "core losses," are due to eddy, or Foucault, currents and to hysteresis effects. Even when the iron cores are laminated to suppress the eddy currents as far as possible, the core loss through eddy currents and hysteresis is considerable, and increases in degree during the use of the apparatus. It is, of course, most desirable to reduce

this loss to the lowest possible limit. Iron, to be used for magnetic purposes, must not only be strong and of high magnetic permeability, but must be of such quality as to give a minimum "core loss." Such iron should have a high electrical resistance, at the same time retaining the desirable mechanical and electrical properties before mentioned.

I have found that the addition of the elements boron or beryllium increases the resistivity of iron to a high degree, at the same time improving its mechanical properties, making a valuable alloy for the above-mentioned purposes.

According to my belief, the resistivity of iron is increased by the presence of alloying elements, to a degree inversely to their atomic weights, because of the increased number of molecules furnished by an element of low atomic weight per unit weight of alloy. In other words, a given weight of alloy, containing given percentages of iron and an alloying element, will have a higher resistance if the atomic weight of the alloying element is low, as a given percentage of the element introduces a relatively greater number of molecules than the same percentage of an element of higher atomic weight.

The novel features of my invention are pointed out in the appended claims.

In making my high resistance alloy, I melt a mixture of commercially pure steel and a suitable portion of "ferro-boron" in a fire-clay crucible as commonly used in the crucible steel process. "Ferro-boron" is an alloy or mixture of iron and boron containing a relatively high percentage of boron, for example, as high as 30 per cent. boron. Ferro-boron is a well-known product and may be purchased in the market. The proportion of boron in the high-resistance alloy may vary from about 0.2 per cent. to 5 per cent. boron, but for most purposes the lower limit of boron content is preferable. The percentage of boron in the finished product may readily be controlled by analyzing the ferro-boron and calculating the amount of ferro-boron to be added necessary to give the desired percentage in the finished product. The steel should preferably be as

free as possible from sulphur, phosphorous or other ingredients. After a thorough mingling and alloying of the iron and boron, or beryllium, the molten mass is cast into ingots and subsequently rolled into desired form by any well-known means. The melting, casting and mechanical treatment of the steel being similar to that given any crucible steel, is so well known as to need no description.

I claim :

A new article of manufacture for use in electrical apparatus, consisting of sheet steel containing boron in amounts varying from 0.2 per cent. to 5 per cent.

963,123, *Dempster (Assigned to General Electric Company), July 5, 1910*

This invention relates to alloys for electrical purposes and has for its object the production of a material having a relatively high specific resistance, which may be easily rolled, drawn, or otherwise formed into desired shape.

One of the objects of my invention is to produce a resistance material suitable for use in rheostats and the like.

In my previous Patent No. 901,428, I have disclosed a resistance conductor having a resistivity of about seventy times that of copper. This material will withstand a red heat continuously, and under this condition will oxidize very slowly. This material is extremely satisfactory for certain purposes, such as electric heaters, where a very high resistance is desired and where it is desired that a high temperature be employed for considerable intervals. This wire is, however, rendered relatively expensive by the fact that it is extremely hard and therefore difficult to draw and roll. For certain purposes, as for instance, in rheostat work, a resistance conductor is desirable which does not have quite such a high specific resistance and which may oxidize more readily than that described in the patent above referred to. I have found that by greatly increasing the amount of iron and reducing both the nickel

and the chromium, I can produce a resistance material suitable for this purpose. The iron content should be more than 50 per cent., while the iron and nickel together should constitute more than 80 per cent. of the alloy. The following composition, however, has given very good results: iron, 70 to 75 per cent.; nickel, 20 per cent.; chromium, 6 to 3 per cent.; manganese, 4 to 2 per cent. In this composition, the main body of the alloy is iron and nickel, since they constitute from 90 to 95 per cent. of the whole content, while the chromium and manganese constitute from 5 to 10 per cent. of the content. Wire made from this alloy is found to have approximately twice the resistance of German silver, and may be produced at a cost which is considerably less than that of German silver. The metal may be drawn and rolled as easily as soft iron, and a uniform product may be produced at a very low cost.

I have described my alloy as being composed of specific materials combined in definite proportions in accordance with the patent statutes, but it is obvious that the materials and proportions may be modified without departing from the spirit of my invention, the scope of which is set forth in the annexed claim.

I claim:

An electrical resistance conductor comprising iron, nickel, chromium and manganese, the iron constituting more than 50 per cent. of the alloy.

1,025,131. Donnell, May 7, 1912

The object of the present invention is, to provide an alloy from which to make plates to be used in the construction of the walls or other parts of safes, having such properties that the operation of perforating them, and especially by the use of a torch, will be hindered and delayed as much as possible, so as to make it practically impossible of accomplishment within the time ordinarily available under the circumstances of a burglary.

To this end the invention consists in the improved alloy to be used in the making of plates adapted to be used in constructing or making the door or the wall of a safe, or to be incorporated therein, that will resist destruction by the action of a torch or an electric carbon pencil to the extent indicated. In selecting the materials for the alloy forming the plate, the principal properties to be considered are fusibility, conductivity of heat and electricity and ductility, as the successful carrying out of the invention depends upon the resultant of these properties. More specifically stated the carrying out of the invention depends upon preventing the fusing or melting of the plate under the conditions available in a burglary.

As between, say, pure iron and copper, the iron is less fusible, *i. e.*, requires a more intense heat to fuse it, than the copper, and if this property only were considered the iron would be the preferable of the two, for the purposes of the invention, but the heat or electric conductivity of copper is much greater than that of iron—so much greater that in carrying out the invention, copper is more effective. This is because when the small flame of the torch is directed against a small localized spot of the plate, if the plate is wholly of iron the heat or electricity is conducted off very slowly and the fusing point of the iron at said spot is quickly reached and the plate destroyed, whereas if the plate is wholly of copper the heat of the torch or a current of electricity is conducted away so rapidly that the copper itself does not reach the fusing point, even at the small localized spot against which the flame or current plays. So it is with steel, instead of pure iron. But it is different with cast iron, which is not an elementary material, but a compound containing iron and other materials in a free state which are good conductors. Pure iron is difficultly fusible and a poor conductor of heat or electricity, but if it contains also a sufficient quantity of some other material that is a good conductor of heat, the compound—the cast iron—becomes a good conductor of heat as well as having a high fusing point. For example, white cast iron and

gray cast iron containing graphitic carbon in a free state have been found to be effective in carrying out the invention, the necessary heat or electrical conductivity being due to the presence of free graphitic carbon in the cast iron. There are many materials known to possess these properties to a greater or less degree, and many of them could be used in carrying out the invention, but, of course, in order to be successful from a commercial point of view, the cost must be taken into consideration. There are many materials on the market that are suitable, but it is not necessary for the purpose of this application to attempt a recital of all of them. Suffice it to say that because of its low cost, its great resistance to fusion, and its good conductivity of heat, gray cast iron is the preferred material for making the plate.

In the preferred, practical carrying out of the invention the plates are made of an alloy containing about 80 per cent. of gray cast iron, about 20 per cent. of copper, which latter adds to the conductivity as well as the ductility of the plates, and a small proportion (say $\frac{8}{10}$ of 1 per cent.) of platinum, which still further adds to the conductivity and ductility of the alloy and also to its resistance to fusion, and this alloy is worked up into plates of the desired thickness, which may be used in any desired manner in the construction of safes. They may be used for making the walls of the door, in whole or in part, or they may be incorporated in the walls or door of whatever construction. In fact the invention resides in the alloy itself and the plates made from it may be used in any manner desired by the builder.

I claim :

An alloy containing cast iron, copper, and platinum in the proportions of about 80 per cent. cast iron, about 20 per cent. copper and about $\frac{8}{10}$ of 1 per cent. platinum.

1,026,461, Schilling (Assigned to Fried. Krupp Aktiengesellschaft), May 14, 1912

The present invention relates to a safe or steel-vault wall which cannot be melted through by the blow-pipe flame of oxyhydrogen gas, acetylene, etc.

It is old to employ a special kind of cast iron for the production of such walls. However, in that case, it is necessary to take into account the disadvantage of brittleness incident to all cast irons.

The object of this invention is to remove this disadvantage. This object is attained by using an iron-carbon alloy having the composition of the steel to which is added a sufficient amount of chromium.

The smaller the carbon content is the greater must the chromium content be. In alloys which, aside from the chromium, contain no other addition affecting the resistance of the alloy against melting the minimum content of chromium must be about 6.5 per cent. for 0.7 per cent. C., about 5.5 per cent. for 1.0 per cent. C., about 4.3 per cent. for 1.4 per cent. C., about 4.0 per cent. for 2.0 per cent. C.

Generally the necessary minimum content of chromium amounts to

$$\frac{5.42}{\sqrt{c}} \%$$

if C indicates the percentage of carbon.

Under certain circumstances it is preferable to add tungsten (W) or silicon besides chromium (Cr). In both instances the required minimum content of the chromium becomes smaller. As silicon is cheaper than chromium the alloy can be made at less cost when an addition of silicon is used. The addition of tungsten further offers the special advantage that the alloy becomes naturally hard if the content of chromium is not too small. This property is possessed, for instance, by an alloy which contains more than 1 per cent. C, 9 per cent. Cr and 3 per cent. W.

I claim:

1. A safe or steel-vault wall made from an iron-carbon alloy having the composition of steel and containing such a high amount of chromium, that it cannot be melted through by the blow-pipe flame of oxhydrogen gas.

2. A safe or steel-vault wall made from an iron-carbon alloy having the composition of steel and containing such a high amount of chromium and tungsten, that it cannot be melted through by the blow-pipe flame of oxhydrogen gas.

1,044,562, Mudge (Assigned to the Cutler-Hammer Manufacturing Company), Nov. 19, 1912

My invention relates to improvements in electric resistances and the process of making the same. It applies more particularly to that form of resistance which is known in the art as "grid" resistance.

According to my invention I employ an alloy of iron and aluminium to make grid resistance. I find that the addition of a definite amount of aluminium to iron, no matter in what proportions the elements of the iron may be combined, results in an alloy the specific resistance of which is much greater than that of cast iron itself. The aluminium may be combined with the iron in various proportions. I have found, however, that if the alloy contains between 2 per cent. and 4 per cent. aluminium, it will have very desirable physical and electrical properties. In practising my invention I have obtained very satisfactory results from such a composition as follows:

Carbon	4.2%
Aluminium	2.5%
Silicon	2.4%
Iron	90.9%
	<hr/>
	100.0%

In this composition the iron contained traces of manganese, phosphorous, and sulphur, as is found in all foundry irons, but in such small quantities that the exact per cent. was not determined. Grids made from an alloy of the above composition had 100 per cent. greater specific resistance than those made from ordinary cast iron. The smaller the cross-section of the convolutions of the grids, the better are the results, as it is a fact that the specific resistance of the alloy, when the alloy is cast in large cross-section, is somewhat lower than when the alloy is cast in small cross-section. Moreover, the specific resistance of the alloy is greater when the grids are cooled slowly.

If 2 per cent. aluminium be added to any specimen of cast iron, the resulting alloy will have at least 30 per cent. greater specific resistance than the cast iron itself.

I prefer that the alloy should have over 4 per cent. carbon or as much carbon as is possible. Of course, the various proportions of the elements in the alloy may be varied under different circumstances. It should be understood that I do not limit myself in any way to the proportions which I have specified as these proportions may be different and still produce the results which I seek.

I claim:

1. An electrical resistance formed from an alloy containing high carbon iron and aluminium.
2. An electrical resistance formed from an alloy containing aluminium, silicon and high carbon iron.

1,044,761, Duke, Nov. 19, 1912

This invention relates to alloys and has for its object to provide an alloy having the merits and advantages of nickel silver and similar alloys without the many objectionable qualities due to their zinc content.

One alloy, remarkable for its cheapness, beautiful silver white color, splendid polish, softness, malleability, ductility and resistance to vegetable acids and oxidation (es-

pecially when its large iron content, over 50 per cent., is considered), is composed of the metals in the following proportions:

	Vols.	Or parts by weight
Iron	12	92.40
Copper	6	53.52
Nickel	4	35.20

One volume of aluminium or 2.56 parts by weight are added during the process of melting a residuum of this metal varying from 1 to $2\frac{1}{4}$ parts by weight is left in the alloy, about $\frac{1}{4}$ part by weight being lost with each remelting.

Where hardness of the alloy is not objectionable or is advantageous I may add from 1 to 2 per cent. of tin.

I do not bind myself to the exact proportions here enumerated, but I keep the iron content between 40 and 52 per cent. by weight. By reducing the nickel and iron content below the content given in the example an alloy can be obtained which is harder, but more liable to become tarnished and oxidized and not of the desired color. The aluminium content may also be slightly varied, an increase in aluminium producing a harder and a decrease a softer alloy. I may also substitute magnesium manganese, phosphorous, sodium potassium, or any other suitable deoxidizing agent in place of or as an auxiliary to the aluminium.

I claim:

An alloy of iron, copper, nickel and a metallic deoxidizing agent having an iron content varying between 40 and 52 per cent. by weight, and a residual portion of about $\frac{1}{2}$ to $1\frac{1}{2}$ per cent. by weight of the metallic deoxidizing agent.

1,057,755, Marsh (Assigned to Hoskins Manufacturing Company), April 1, 1913

My invention relates to an electrical resistance element adapted for general use, but more especially for use in heating appliances. For this use, the first requirement is durability, and it is with the greatest difficulty that durability can be predetermined, although it can readily be discovered by actual test.

I have discovered by test that in general metals of the eighth group, fourth series, of the elements as classified by Mendelejeff in the periodic system of elements (that is, iron, cobalt and nickel), when alloyed with silicon, give rise to materials having the property of great durability under the conditions of use.

In practice, I prefer to use the metal nickel, alloyed with silicon in the proportion of about 5 per cent. of silicon. I have succeeded in rolling alloys running as high as 7 per cent. silicon with nickel, although the alloy is so hard as to interfere somewhat with the facility of the operation. The art of rolling and drawing metals is advancing rapidly, however, and it is probable that higher percentages can be rolled in the future as the art develops.

Cobalt is generally interchangeable with nickel for the purpose intended, as I have determined by long experience and testing resistance elements of various compositions. The principal difference between the two consists in the fact that cobalt alloys work easier hot and nickel alloys work easier cold. Iron, when alloyed alone with silicon, in the proportions mentioned, or in fact in any proportions where the silicon shows its effects in increasing durability, is so brittle that I have not succeeded in rolling it, but mixtures of iron with cobalt or nickel, or both can be worked readily when alloyed with silicon in the proportions named. In fact, the difference between the three metals—iron, cobalt and nickel—when alloyed with silicon for the purpose intended, lies principally in the ease with which a resistance element can be manufactured from them, and not

those properties inherent in the alloy which become important in the use of the element.

My preferred element, formed as above mentioned, has a resistivity of approximately 37 microhms per centimeter cube, which is quite high enough for convenient manufacture of translators, although not as high as some elements available on the market and, although I have not tested the resistivity of all the mixtures possible of the several metals specified, it is highly probable that the mixtures of the metals iron, nickel and cobalt, or some of them, when alloyed with silicon in the percentages named, will give still higher resistances. For instance, nickel alloys in which the nickel is 30 per cent. are known to give resistivities of approximately 85 michroms per centimeter cube, and while the addition of the silicon will greatly augment the durability of such an alloy, as I have discovered, it doubtless will not greatly decrease the resistivity, and may somewhat increase it. It will, of course, be understood that deoxidizers, such as manganese, may be used, in addition to the metals herein specified, for its ordinary purposes, and I find that when added in a slight excess, it does not injuriously affect the alloy or the element formed therefrom, but on the contrary, a slight excess when added to the nickel silicon alloy makes working easier. However, with the cobalt silicon alloy I do not find it necessary to use the excess manganese.

I claim:

1. An electric resistance element composed of metal of the eighth group, fourth series, Mendelejeff's table, and silicon.
2. An electric resistance element composed of metal of the eighth group, fourth series, Mendelejeff's table, and silicon, the silicon in the quantity of approximately 5 per cent.
3. An electric resistance element formed of an alloy of nickel and silicon.

My invention relates to improvements in articles of manufacture which are subjected, when in use, to external heat at high temperatures, such temperatures ranging from 1000° F. upward.

It has for its object to produce an article which shall be strong and durable and capable of resisting injurious corrosion, pitting and oxidation at such temperatures to a remarkable extent.

It also has for its object to produce articles which, when in use, will have remarkable qualities as hereinafter specified.

My invention relates to such cast articles as moulds for die casting and other uses, valves and valve seats for internal combustion engines, crucibles, outer casings for crucibles, linings for moulds and crucibles, annealing boxes, case hardening or carburizing boxes, articles including tables, moulds, plungers and conveyors for use in the working of glass and other massive articles, and consists of forming such articles from an alloy containing nickel or cobalt and chromium in certain proportions. The alloy requires a very high melting heat, but when once sufficiently melted can be cast in the ordinary manner.

In carrying out my invention I use an alloy containing from 5 to 30 per cent. of chromium and from 50 to 90 per cent. of nickel (or cobalt), the combined nickel (or cobalt) and chromium being at least 60 per cent. and the greater part of the remainder being of iron. The following is the preferred composition of the alloy used in carrying out my invention, viz., nickel, 60 per cent.; iron, 26 per cent.; chromium, 12 per cent.; manganese, 1½ per cent. When the article is to be machined the alloy should be substantially carbon-free, the carbon not exceeding 0.40 per cent. Iron, nickel and cobalt belong to the same group of metals in Mendeleeff's table and have approximately the same atomic weights, to wit, iron, 55.85; nickel, 58.68, and

cobalt, 58.97 and cobalt may be substituted for nickel in carrying out my invention, since it has substantially the same properties as nickel.

Internal combustion engine valves formed according to my invention do not become pitted or corroded or warped, so as to require frequent scraping or periodic regrinding, as is the case with valves as at present made.

Moulds embodying my invention are not liable to serious oxidation or other injury when used in casting brass or other similar metals and are so strong that they can be used for long periods for die casting. They produce smooth castings for the reason that the surface remains smooth even under the trying conditions of temperature changes and high temperatures, and they resist chemical actions to which old types of moulds are liable. On account of their low heat conductivity they prevent the castings from chilling before removal, thereby producing castings of materials such as iron that can be easily machined. Moulds embodying my invention are particularly useful in the manufacture of glass articles, such as glass bottles, since they withstand the high temperature and abrasion to which they are subjected in a remarkable manner and produce more highly polished glassware because they can be used at a higher temperature than other materials without the glass sticking or adhering thereto, and also resist the chemical action due to the constituents of glass. On account of the strength of the material they can be made much lighter than cast-iron moulds.

Tables, rolls, drawing dies for glass working when made according to my invention are so slightly oxidized or corroded when in use that they can be used for a very long time without refinishing. Conveyor links for conveyors employed in moving or transmitting hot sheets of glass are also remarkably enduring when made according to my invention.

Crucibles when made according to my invention easily withstand temperatures sufficiently high for melting of brass or other materials of similar high melting point and

are substantially unaffected by the molten metal. While the alloy specified is of relatively low heat conductivity when compared with other alloys or metals, it is of much higher heat conductivity than graphite or magnesite heretofore used in the construction of crucibles, so that for this reason and also for the reason that the crucible, when made according to my invention, may be thinner than crucibles heretofore used, the contents of the crucible can be more quickly brought to the melting point. The material of the crucible does not affect the quality of the molten content. Furthermore, crucibles made according to my invention can be heated and cooled quickly without damage to the crucible so that with crucibles embodying my invention not only can a purer product be obtained, but a great saving in time can be achieved. A very considerable saving can also be achieved by reason of the fact that the crucibles are not liable to be broken and retain their strength when heated to temperatures that would destroy ordinary iron or steel. Moreover, the stock of crucibles necessary to be kept on hand can be much smaller. The same is true of the stock of moulds for glass making and annealing boxes. In glass making, as heretofore practiced, the renewal of moulds is necessarily frequent and necessitates the stopping of the glass casting machine, resulting in a great loss of time, which is saved by using moulds embodying my invention, and the doing away with the necessity of frequent refinishing of the moulds by the use of my invention results in a further great saving of labor and expense.

The manganese appearing in the preferred form of the alloy as above specified is not essential in producing my results, but is merely the remnant of manganese used in forming the alloy. Where the article in its course of manufacture is to be machined, the carbon should preferably not exceed 0.40 per cent., but where the article is cast and does not require machining, it may be considerably higher, such for instance, as 2 per cent.

When subjected to oxidizing atmosphere of high temperature, a slight film of oxide forms on the surface of the article which is strong and durable and strongly resistant to the action of acids such as sulphuric and hydrochloric and of alkalis. This oxide is non-flaking, adhering strongly to the mass and when formed offers an increased resistance to corrosion, pitting and further oxidation. The mass when low in carbon is easily machined and may be rolled and forged.

I claim :

1. A cast article of manufacture subjected when in use to external heat at high temperatures composed of an alloy containing chromium and iron and another metal of the iron group of substantially the same atomic weight as iron, the chromium being from 5 to 30 per cent., and the metal last referred to from 50 to 90 per cent., and the combined third metal and chromium amounting to at least 60 per cent.

2. A cast article of manufacture subjected when in use to external heat at high temperatures composed of an alloy containing nickel and chromium and iron, the chromium being from 5 to 30 per cent., and the nickel from 50 to 90 per cent., and the combined nickel and chromium amounting to at least 60 per cent.

1,263,831, Wolfard (Assigned one-fourth to Ames and one-fourth to Kent), April 23, 1918

This invention relates to improvements in compositions of matter for resisting heat, without cracking or crumbling under severe conditions, and in methods of making the same.

I have discovered that a certain amount of nickel alloyed with iron will make a product having characteristics which are adapted to withstand these conditions, and which, so far as I am aware, are not possessed by the previously

known material that is available for use under commercial conditions.

In the best form in which I have made experiments I have found that a composition of about two-fifths nickel and three-fifths iron has qualities which fit it for attaining the above described results. My experiments, however, show that these proportions can be varied, so that I believe a proportion at least as low as one-third of nickel, or as high as two-thirds of nickel, the remainder being iron would be satisfactory. My experiments also indicate that while purity of the iron is not essential better results are attained with a small percentage of carbon. The alloy may be made by melting together the desired amount of nickel and of iron, according to methods usually employed in the art, and can be handled upon cooling from the molten state by the usual methods of handling metals. It is a particular advantage of this alloy that it is to be cast in its desired form, and that when so cast makes a product which is free in a marked degree from blow holes and other defects. Such castings have a firm, compact and homogeneous structure which may be easily machined to any desired shape. In common with other metals it has the property of being tenacious at ordinary temperatures, but unlike other metals it retains a high degree of tenacity at high temperatures, and under conditions under which all other commercially available metals known to me have failed. With respect to tenacity it is of course entirely different from materials such as porcelain and other earthen substances, commonly called refractory, both because such substances are apt to be porous and so not adapted either to conduct or to confine gases under pressure, are always more or less fragile, are not easily shaped to conform precisely to a machined surface, and also because they will crack and crumble under the influence of heat. Without knowing with certainty the chemical explanation for the novel results attained, I believe that it may be that the nickel prevents oxidation of the iron, and the iron prevents crystallization of the nickel. Whatever the explanation may be,

it appears that a rather wide variation may be made in the composition of the alloy while still producing a metal having superior heat resisting qualities.

The composition of the invention can be applied to many uses in the arts:

I claim:

1. A wall shaped and adapted to confine material at high temperature, comprising an alloy of nickel and iron having an internal organization such as results from solidification from a liquid state in approximately its said shape, the nickel constituting about one-third to two-thirds of the whole.

2. A wall shaped and adapted to confine material, said wall being in a state of internal stress resulting from great temperature differences between adjacent parts thereof and being an alloy of nickel and iron substantially as described, the nickel constituting about one-third to two-thirds of the whole.

See U. S. Patent 1,057,828 on page 25.

See U. S. Patent 1,093,557 on page 125.

1,273,877, Kuehnrich, July 30, 1918

The object of this invention is to provide an improved alloy possessing the qualities and endurance almost exclusively associated heretofore with high speed tool steel. An alloy according to the present invention comprises a base of nickel, chromium and silicon to which a substantial quantity of aluminium has been added. It is to the presence of this aluminium in the alloy that its peculiar properties are due, enabling it to be used as a substitute for high speed steel. The hardness of the alloy is determined by the amount of aluminium, but when excessive quantities of the latter are added the alloy becomes too

brittle for use for high speed tools. The nickel may be partially replaced by cobalt.

In carrying out the present invention a base alloy of nickel, chromium and silicon is first melted. The proportion of chromium may vary from about 10 per cent. to 35 per cent. or possibly more, while the silicon content may also vary, 3 per cent. or even less giving satisfactory results, but the amount of silicon may be considerably increased. When the base, which should preferably contain not less than $\frac{1}{2}$ per cent. of carbon, is sufficiently molten there is added a substantial quantity of aluminium, about 6 per cent. of the whole, but the percentage of aluminium may vary from 3 per cent. to 20 per cent. according to the hardness required. When the aluminium has been melted and proper admixture has occurred the alloy is teemed.

The alloy thus made is cast into tools in metal or sand moulds, the former being preferred. The castings are ready for use without any additional heat treatment, their cutting edges merely requiring to be ground. They are found to be excellent high speed tools.

Although the alloy according to this invention is mainly intended for the manufacture of high speed cutting tools it may be used for other purposes, such as the valves of internal combustion motors, where a metal is required to retain its hardness at high temperatures.

In making the alloy according to this invention, the chromium may be added in the form of the metal or the alloy known as ferro-chrome containing about 70 per cent. more or less chromium, as the iron and carbon contained therein do not adversely affect the properties of the new alloy.

The following mixture has been found in practice to give excellent results:

Ferro-chrome (containing about 70 per cent. chromium and 4 per cent. carbon)	8 lbs.
Nickel	21 lbs.
Silicon	1 lb. 11 ozs.
Aluminium	2 lbs. 8 ozs.

In the base alloy of nickel, chromium and silicon in about the relative proportions described the nickel may be partially replaced by cobalt.

I claim :

1. A metal alloy composed of nickel, approximately 10 per cent. to 35 per cent. of chromium, approximately 3 per cent. to 7 per cent. of silicon, and from 3 per cent. to 20 per cent. of aluminium.

2. A metal alloy composed of nickel, approximately 10 per cent. to 35 per cent. of chromium, approximately 5 per cent. of silicon, and approximately 6 per cent. of aluminium.

BRITISH PATENTS

CLASS 3-B

553 of 1858, Webster

Three alloys are described: No. 1 consists of 3 parts of nickel; 6 of copper; 12 of tin, and 1 of antimony. No. 2, of 20 parts of tin; 2 parts of No. 1 alloy and $\frac{1}{4}$ part of antimony. No. 3, 20 parts of copper; 20 parts of zinc, and $1\frac{1}{2}$ parts of No. 1 alloy. As an alternative to No. 3, 21 parts of copper; 15 parts of zinc, $1\frac{1}{2}$ parts of alloy No. 1 may be used with the optional addition of lead. The alloys thus obtained may be used for reflectors, as substitutes for German silver or Britannia metal, or where a hard, white metal, having little tendency to tarnish, is required. In melting, care is taken to diminish the volatilization of the antimony and zinc by passing them beneath the non-volatile metals whilst the latter are being heated in a furnace.

2,489 of 1862, Vigoroux

Three inoxidizable and acid resisting white metal alloys have the following percentage compositions: Tin, 78.5, 80.7 or 71.5; antimony, 19.5, 17.5 or 21.5; nickel, 2.0, 1.8, 7.0.

The last combination is the strongest. The first is of a steel white color and of ornamental appearance.

446 of 1863, Bousfield

An alloy consisting of 60 per cent. of copper, 20 per cent. of nickel and 20 per cent. of zinc, may be used in the cartridge chamber of a firearm as it resists the explosive force, the heat and oxidation.

3,941 of 1868, Bousfield

A non-corrodible alloy is composed of nickel and copper free from zinc, or from aluminium alone or alloyed, or from an alloy of gold or silver, or from combinations of the above. An alloy containing from 50 to 65 per cent. of nickel, with 30 to 45 per cent. of copper is non-corrodible.

See British Patent 1,923 of 1872 on page 98.

See British Patent 1,143 of 1877 on page 99.

See British Patent 3,420 of 1877, on page 99.

See British Patent 3,394 of 1880 (this corresponds to U. S. Patent 250,326 on page 232).

See British Patent 5,218 of 1880, page 100.

22,023 of 1894, Moissan

This discloses a process for alloying with refractory metals such as molybdenum, tungsten, uranium, zirconium, vanadium, silicon, chromium, titanium, iron or steel, bronze, etc. An alloy of the refractory metal and aluminium (or magnesium) is first obtained by adding the oxide of the refractory metal to molten aluminium to reduce it. The alloy of the aluminium and the refractory metal so obtained is then added to the metal or alloy with which the refractory metal is to be alloyed, and the aluminium removed in the slag, or by special means. In this manner very refractory alloys may be produced.

202 of 1896

This corresponds to U. S. Patent 573,615 on page 74.

24,878 of 1898, Brookes

A workable alloy is prepared by adding 10 to 30 parts of magnesium to 100 parts of aluminium. Different quali-

ties in the alloy are obtained by varying the amount of magnesium. Nickel, copper, or German silver may be added to the alloy in sufficient quantities to raise the specific gravity to that of pure aluminium.

The new alloy has a hardness and strength so great that even axes, cock-pegs, etc., could be made from it. The color is nearly silver white, and the polish can be carried to brilliancy and is of an extraordinary resistance to the influence of the atmosphere.

23,644 of 1902, Just, Jenkins, Frith

Relates to an alloy containing copper, nickel, lead, tin, zinc, palladium, iron, aluminium, vanadium, and phosphorus, for bearings, sheets, tubes, wire, water, gas, and electric fittings, instruments, artistic work, coins, and other stamped articles, and torpedoes and torpedo boats. The alloy is obtained by successively charging into a heated crucible about 67.6 lb. of copper; 1.3 lb. of phosphorus, either in the form of yellow phosphorus or as phosphor copper; 12 lb. of powdered borax; $\frac{1}{2}$ lb. of burnt sienna; 32.5 lb. of nickel; 1 lb. of horseshoe nails or other iron articles; 1 lb. of sheet lead; 1.3 lb. of grain tin; 26 lb. of zinc; $\frac{1}{5}$ oz. of palladium sodio-chloride or other palladium salt; 1 lb. of powdered glass or equivalent material; 12 oz. of aluminium; $\frac{3}{5}$ oz. of ammonium vanadate or other vanadium salt, and 1.3 lb. of phosphorus, either in the form of yellow phosphorus or phosphor copper, or equivalent proportions of these substances. Before adding the borax, the molten metal is covered with crushed coke or similar material. One or two of the elements vanadium, phosphorus, or palladium, may be omitted from the mixture. When a yellow alloy is required, $18\frac{1}{2}$ oz. of silver; 3 oz. of arsenious oxide or other arsenic compound; 36 lb. of copper; 18 lb. of tin, and $21\frac{1}{2}$ lb. of common brass, or equivalent proportions of these substances are added to the mixture in the crucible. A little zinc is added each time the alloy is remelted.

This alloy has about the color of silver and takes about the same polish. It has a greater tensile strength, about equal to that of a steel containing less than 0.20 per cent. of carbon. It does not tarnish or oxidize when exposed to atmospheric influences nor is it affected even by an atmosphere containing sulphuretted hydrogen or sulphuric acid. It is not affected by salt, sea, or alkaline waters, nor is it affected by alcoholic liquids, fats or oils nor by fluid or vegetable acids of any kind. It has great value as an anti-friction metal. It has a melting point of about 1100° C. or 2012° F. It can be rolled into very thin sheets and drawn into thin tubes or very fine wire. It can be spun, soldered, brazed and annealed.

It is a great resistant of electricity.

23,861 of 1903, Soc. Anon La Neo Metallurgie

An iron-nickel-chromium alloy melted and refined by any known process and manufactured in an electric furnace, contains only 0.3 to 0.8 per cent. of carbon, 0.15 to 0.3 per cent. of silicon, 0.04 to 0.06 per cent. of sulphur and 0.01 to 0.015 per cent. of phosphorus. The iron in it generally varies from 16 to 38 per cent., the nickel from 5 to 60 per cent. and the chromium from 24 to 57 per cent. This alloy being readily dissolved in iron and steels by fusion, and is used in the manufacture of cast iron and of steels in general. It gives great resistance to corrosion.

4,698 of 1904, Guillaume,

The steel used in compensated balances for chronometers, etc., is replaced by an alloy of nickel with at least 7 per cent. of chromium, sometimes with the addition of 1 per cent. of manganese, the object being to render the nickel non-magnetic and more rigid. This takes the place of a platinum alloy.

6,945 of 1904, Jacobson

Two alloys of iron, nickel, aluminium, and copper, one without zinc, and one with zinc, are described. The former consists of the metals in atomic proportions, two atoms of iron and of copper being combined with one atom of zinc and one of nickel. The iron and nickel are heated together, one-tenth of the aluminium is added, then the copper, and finally the remainder of the aluminium. This alloy is not attackable by sea water, water, moist air or by most acids. It is as hard as nickel steel, and has greater strength.

18 of 1906, Hatfield

Silicon alloyed with carbon, iron, copper, or platinum may be employed for making electric resistances, contacts, and the like.

Silicon has a high resistance, and when in the massive form is extremely hard, and chemically inert even at high temperatures. It also has a low coefficient of expansion, and a high specific heat. The clamp or connecting conductor is made of a nickel steel alloy whose heat coefficient of expansion is the same as that of silicon, to always insure good contact.

2,129 of 1906, Boulton

An alloy of low electric conductivity, non-oxidizable, tough, and ductile, for use in electric resistances is produced by combining chromium, molybdenum, tungsten or uranium with a larger proportion of nickel or cobalt, or of a metal having similar properties, excluding iron. Chromium is preferred and 25 per cent. of that metal and 75 per cent. of nickel or cobalt is found advantageous. The material may be formed into wire strips, strands, or filaments. Specification No. 202 of 1896 is referred to. Such

an alloy keeps a polish even in the presence of corrosive fumes.

See British Patent 9,750 of 1906 (this corresponds to U. S. Patent No. 856,392 on page 10).

8,539 of 1907, Boulton

Alloys for electric resistances consist of nickel or cobalt, and optionally a metal of the chromium group with a small proportion of aluminium or of any other element more electric positive than nickel and having an oxide which melts above 1200° C., such as tin, silicon, or manganese. Such an alloy has a high electric resistance and high melting power, and may be formed into a wire or strip, which then heated acquires a tough, thin coating of oxide preventing further oxidation.

27,217 of 1909, Akt Ges. Brown Boveri et. Cie.

Steam turbine blades are made of an alloy of pure iron and nickel without any trace of carbon. The alloy is manufactured, for example, in an electric furnace, so that no carbon comes into contact with it. This alloy does not rust.

12,757, British Thomson-Houston Co., 1910

See U. S. Patent 963,123 on page 245.

14,744 of 1910, British Thomson-Houston Co.

An electric resistance alloy containing principally nickel, iron, and chromium as described in Specification No. 26,940/07 has a carbon content of from 0.1 to 0.4 per cent.

29,469 of 1910, Duke

This corresponds to U. S. Patent 1,044,761 on page 251.

Aluminium alloys contain cadmium, copper, lead, mercury, nickel, and optionally magnesium. In the preparation of the alloys 3 parts of copper and 3 parts of nickel are first added to a fused flux consisting of 60 parts of borax, 5 parts of magnesium sulphate, 10 parts of copper sulphate, 7 parts of copper nitrate, 1 part of mercuric sulphate, 2 parts of cadmium sulphate, 15 parts of nickel sulphate. When the mass is in a quiet fluid condition 3 parts of tin, 1 part of lead and 90 parts of aluminium are added. Bauxite may be used instead of aluminium in which case the final stage of the treatment is affected in an electric furnace for the extraction of the aluminium. The resultant alloy is a stock-metal with which aluminium, tin, lead, copper and nickel are subsequently alloyed, to obtain soft or ductile alloys, or hard alloys.

These alloys are bright and white in color and can be brazed, soldered, turned, rolled, forged, or welded. They are highly resistant to oxidation by atmospheric and weather influence.

Iron, nickel, cobalt and their alloys with one another are obtained in the passive state by alloying them in quantities ranging between 65 and 72 per cent. with between 34.5 and 25 per cent. of chromium and between 5 and 0.3 per cent. of one or more of the metals molybdenum, tungsten, platinum, iridium, osmium, palladium, rhodium and ruthenium together with one or more of the metals gold, silver, and copper in a total amount ranging between 2 and 0.2 per cent. Impurities such as carbon, silicon, etc., may be removed during the melting of the metals by adding oxides of these metals, the final traces of oxygen being removed by an addition of magnesium or magnesium alloys.

6,062 of 1915, La Roche

The following alloy of steel is inoxidizable and is stronger and harder than ordinary steel:

Steel	80%
Chromium	5%
Nickel	10%
Vanadium	5%

103,112, Driver-Harris Co., March 7, 1917

This corresponds to No. 1,190,652 on page 255.

GERMAN PATENTS

CLASS 3-A

281,784, Borchers and Borchers, 1915

This is an addition to German Patent No. 278,903. In experiments which attempted to utilize the nickel alloys protected by our patents, which are almost completely resistant to oxidizing acids, for lightning conductors, contacts, points of electrodes and similar apparatus which produces electric discharges or sparks, we have found that even at moderately high temperatures, even if a weak glow takes place at the contacts made of our alloys, destructive oxidation takes place. This oxidation is lessened by increasing the amount of the addition of gold and the metals the platinum group as suggested in German Patent No. 278,903. We have achieved the same durability with our alloys, as with electrodes and contacts made of the platinum metals, by increasing the percentage of the platinum metals to about 25 per cent. The resistance of the alloys against the action of the said sparks is still slightly better by further increasing the amount of platinum. It reaches a practical maximum when from 30 to 40 per cent. of platinum metals have been added, as the increase of the resistance is no longer in proportion to the cost.

For electrodes which are subject to heavy duty, the addition of platinum is to be over 30 per cent., but below 40 per cent., while for contacts on which lesser demands are made, the addition of platinum can be from 10 to 30 per cent.

GERMAN PATENTS

CLASS 3-B

See German Patent 54,846, page 118.

66,937, Solvisky, 1893

An aluminium alloy which has great resistance to oxidation is made by adding nickel (or cobalt) as well as cadmium. The first increases its hardness and the second its ductility.

Since the nickel or cobalt can only be alloyed with aluminium imperfectly and with difficulty, they are added in the form of a tin alloy, which has a melting point as near as possible to that of aluminium. Thus, 50 parts of nickel and 50 parts of tin have a melting point of about 800° C. Some of the alloys are as follows: Aluminium, 90 per cent.; nickel, 1 per cent.; tin, 5 per cent.; cadmium, 4 per cent. This has about half the hardness of iron. Another alloy is as follows: Aluminium, 95 per cent.; nickel, 1 per cent.; tin, 1 per cent.; cadmium, 3 per cent. The aluminium and the nickel alloy are first melted together, and then the cadmium is added.

242,313, Borchers and Schirmeister, Jan. 3, 1912

An alloy composed of from 0.8 to 1.2 per cent. of tungsten, 8 to 10 per cent. of cobalt, the remainder being aluminium, is much harder than aluminium, can be worked much better and is more resistant to atmospheric influences. Another alloy is made up of 0.6 to 1 per cent. of molybdenum, 9 to 10 per cent. of cobalt, the remainder being aluminium. These alloys are made according to the known methods.

PREFACE TO CLASS 4

It has been deemed desirable to put the white jewelry alloys into two classes, those containing precious metals and therefore costly, and the alloys of non-precious metals. Many combinations are possible of metals which will present the luster and hardness of platinum, but the manufacturing jeweler should readily find in this list an alloy suitable for his purpose.

These patents show that it has been known for many years that white alloys could be made by combining gold and silver, gold and aluminium, etc. The efforts of inventors have been directed towards making workable white alloys embodying a large amount of gold, and since only a small percentage of aluminium is required in a gold aluminium alloy for imparting a white color, we have included some patents upon the alloying of aluminium so as to render it workable, in the hope that they will convey some suggestions to the trade

U. S. PATENTS

CLASS 4-A

See U. S. Patent 1,096,655, on page 187.

Reissue No. 13,961, Zimmerman (Assigned to Baker & Co., Inc.), Aug. 10, 1915

This invention relates to alloys of platinum and osmium which combine in a high degree the property of great hardness with tensile strength and are applicable for use in the arts, chiefly for jewelry, electrical and scientific purposes.

Heretofore platinum has been alloyed with iridium in various percentages. The higher the percentage of iridium which is added to the platinum, the greater is the resulting hardness. The highest percentage of iridium alloyed with platinum is about 30 per cent. The alloy of platinum and iridium is known in the trade as "iridio platinum," or in short "hard platinum."

The steadily increasing demand for hard platinum, the limited supply of iridium and its high price, have created a demand for another hard alloy of platinum with a precious metal which can be supplied at less cost than the iridio platinum.

I have found by a series of practical tests that the addition of osmium to platinum greatly increases the hardness of the platinum. The percentage of osmium which has been alloyed by me with platinum varies from less than $\frac{1}{2}$ of 1 per cent. to 10 per cent. or more. Alloys of platinum and osmium containing more than 10 per cent. of osmium are only workable with difficulty, while alloys containing

a percentage of osmium higher than 30 per cent. are brittle and hardly workable. It was further found that by alloying platinum with osmium, as far as hardness is concerned, one part of osmium is the equivalent of $2\frac{1}{2}$ parts of iridium, and that the tensile strength of the alloy is very high, so that a fine wire of platinum-osmium is more easily produced than a fine wire of iridium-platinum of the same hardness. It was further found that an alloy of platinum and osmium containing 2 per cent. of osmium and 98 per cent. of platinum can be advantageously used, for jewelry work, it being hard and tough, while alloys containing 90 per cent. to 94 per cent. of platinum and 10 per cent. to 6 per cent. of osmium will replace iridium platinum containing from 15 per cent. to 25 per cent. of iridium for contact-points in electrical apparatus. As there is very little demand for osmium, the same can be obtained at a much lower cost than the more expensive iridium, while it is in every other respect when alloyed with platinum, as regards hardness and tensile strength, the equal of iridium-platinum. The osmium-platinum alloy is also more resistant to the action of acids than platinum.

For melting platinum and osmium together, it is necessary to refine the platinum and osmium of commerce to a high degree of purity so as to remove from the platinum the small quantities of metals of the platinum group and other impurities, and the impurities contained in the osmium. It is well known that platinum, as found in nature, contains osmium as well as other metals of the platinum group; also copper and iron, but it is impossible to make use of this natural product as an alloy, as the presence of the other metals impairs the good properties of the osmium-platinum alloy.

The new alloy herein described, which is obtained by melting together refined platinum and refined osmium, combines great tensile strength with hardness and ductility, and is thereby adapted in a high degree for application in the arts.

I claim:

Alloys of platinum and osmium, containing refined platinum and refined osmium in the proportion of less than $\frac{1}{2}$ per cent. to 30 per cent.

1,165,448, Richter (Assigned to Dr. Richter & Co.), Dec. 28, 1915

Gold alloys of a white color are known, for instance gold-aluminium, gold-iron, gold-nickel, gold-palladium, gold-platinum, gold-tin. These alloys, which all consist of only two metals, have, however, certain disadvantages which hinder their technical application. As to the binary (and certain ternary) alloys of gold with platinum and palladium, these are much too costly for practical use; for such white gold alloys must be sold at such a price as is equivalent to that of an ordinary gold alloy of equal content of gold. The alloys with aluminium, tin, nickel and the like, present, indeed, no particular difficulty in respect to their cost, but they are so hard and brittle that they cannot be worked.

According to the present invention, alloys which fulfill in every respect the requirements of practice, can be made by substituting more or less for metals of the palladium group (palladium, iridium, osmium, ruthenium, rhodium) a metal of the iron nickel group, particularly nickel. In this manner alloys are obtained, the manufacture of which is not substantially dearer than that of the ordinary gold alloys, while on the other hand the brittleness produced by addition of nickel alone is removed completely by the combination of nickel with the noble metal, the said alloy being malleable and adapted to be formed into articles of jewelry. Obviously, instead of pure gold, copper-gold alloys may be used as the starting material. In this case, however, the content of copper must not exceed a certain limit, because an excess is attended by a passage of the desired white color into a reddish tint. By a correct choice of the proportions it is possible to obtain alloys which consist of gold,

copper and nickel alone without any other noble metal, and yet exhibit substantially the desired properties.

The composition of the alloy may vary within wide limits. Investigation has shown, however, that the most advantageous composition for the alloy to be added to the gold is as follows: Palladium 0.5 to 20 atoms per cent. A metal or metals of the nickel group 70 to 94 atoms per cent. Copper 4 to 30 atoms per cent. This addition is considered as a whole, that is to say if, for example, the alloy consists of x per cent. gold and $100-x$ per cent. of the addition, the latter has the composition given above in per cent.

A suitable composition of alloy made in accordance with my invention may be, for example, as follows: Gold, 57 atoms per cent.; nickel, 7.5 atoms per cent.; palladium, 35 atoms per cent.

By atoms per cent. I mean percentages based on the atomic weights of the quantities of the metals present in the alloy.

I claim:

1. A malleable, non-brittle white alloy comprising gold, palladium and a metal of the iron-nickel group, substantially as and for the purpose described.

2. A malleable, non-brittle white alloy comprising gold, palladium and nickel, substantially as and for the purpose described.

1,169,753, Peschko, Jan. 25, 1916

My invention relates to alloys particularly designed for use as substitutes for platinum in the manufacture of jewelry, scientific instruments, dental supplies and electrical apparatus, one object being to provide alloys which while cheaper than platinum shall not be inferior to it for the purposes noted, as regards certain of their qualities.

It is further desired to provide alloys which, with possible exception of those containing from 70 per cent. to 80

per cent. of gold, shall possess a color such as will render them indistinguishable from platinum, it being particularly desired that said alloys be relatively soft, easily workable, shall possess a tensile strength higher than that of platinum, shall be capable of receiving a high polish, and shall have wearing qualities practically equal to those of platinum.

In carrying out my invention I fuse together platinum, palladium, and gold, and while the proportions of these metals may be considerably varied without departing from my invention, in a typical case I employ particularly for dental supplies, an alloy containing 10 parts of platinum, 30 parts of palladium and 60 parts of gold. The palladium is employed mainly for the purpose of increasing the bulk of the product for a given weight thereof as well as for the purpose of making the resulting alloy workable and the gold is used mainly for the purpose of reducing the cost of the product.

If it be desired to produce an alloy having an increased tensile strength and greater hardness than those described above, I may add such metals as ruthenium, iridium, osmium, or rhodium in the proportion of from 1/10 per cent. to 2 per cent., it being noted that one of these hardening metals may be used alone or several of them together may be employed.

For the purpose of making the alloy, an oxy-gas flame or an electric furnace may be employed, with a lime, magnesium or graphite crucible, although the actual method of procedure in combining the metals constituting my alloy forms no part of the present invention.

It is to be noted that all of the above described alloys are practically insoluble in mineral and organic acids, with the possible exception of the high silver alloys which are slowly attacked by nitric acid and boiling sulphuric acid. All of the alloys are soluble in aqua regia. A valuable feature of the alloys resides in the fact that they do not discolor or oxidize in air at temperatures below their melting

points and will in every case take a high polish equal or superior to that characterizing platinum.

I claim :

1. An alloy containing 10 parts of platinum, 30 parts of palladium and 60 parts of gold.

2. An alloy containing platinum, palladium, gold and a metal having the property of increasing the tensile strength of the alloy, the gold being in excess.

3. An alloy containing platinum, palladium, and an excess of gold.

4. An alloy containing platinum palladium, and an excess of gold, with from $1/10$ to 2 per cent. of a hardening metal.

5. An alloy containing platinum, palladium, and an excess of gold, with from $1/10$ per cent. to 2 per cent. of iridium.

BRITISH PATENTS

CLASS 4-A

4,396 of 1882, Guye

This invention relates to the manufacture of a series of alloys of gold with aluminium bronze, and with other alloys of aluminium and copper and an important feature of the invention is the method of preparing the alloys whereby the contamination of the aluminium by the silica of the crucible is prevented and whereby the alloys are endowed with qualities of malleability and ductility which fit them admirably for general use in the arts in substitution of the gold, silver and copper and gold-copper alloys now generally employed. No such alloy has, I believe, ever yet been produced sufficiently malleable and ductile to enable it to be used in the goldsmith's art.

By alloying pure gold with aluminium and copper in any of the ways hereafter described, and in proportions varying according to the desired standard of the ingot, a series of alloys of gold are obtained, varying from the highest to the lowest standard of a fine gold color, malleable, ductile, hard and elastic, and much less oxidizable in the air at ordinary temperatures or at a red heat than the alloys of gold now generally employed, and of a lower density (or in other words, having a greater specific volume) than the latter, the comparison in each case being made, of course, between corresponding standards.

The preparation of these alloys may be made in any earthenware crucible, whose composition does not contain such a high proportion of silicon as would render the alloy brittle, a consequence which may probably be attributed

to the form of aluminium silicates or silicide of aluminium.

Equally good results are obtained by alloying the gold with aluminium bronze, or with a mixture in corresponding proportions of copper and aluminium, or successively with these two metals.

Equally good results are obtained by alloying the gold with aluminium bronze, or with a mixture in corresponding proportions of copper and aluminium, or successively with these two metals.

In the latter case it is essential to alloy the gold first with the copper and afterwards with the aluminium.

The aluminium bronze used for the purpose of the invention should contain about 10 parts of aluminium and 90 parts of copper, but the proportion of aluminium may be increased or diminished according to the degree of ductility and malleability, and the color it is desired, the alloy should have. Thus, to obtain alloys of a pale gold color the proportion of aluminium contained in the aluminium bronze may be increased to about 15 per cent., the alloy of gold becoming paler and harder as the proportion of aluminium is increased. On the other hand if a redder and more malleable alloy is required, the proportion of the aluminium contained in the aluminium bronze may be diminished to 4 or 5 per cent. or even to 1 per cent., but if a lower proportion of aluminium than 4 per cent. be taken, the alloys will be more liable to be oxidized at a red heat.

The chief practical difficulties to be overcome are due to the fact that the aluminium becomes easily contaminated by contact with the ordinary earthen crucibles, and that if heated for too long a time it tends to become oxidized. Both these objections are avoided at once by taking care to add the aluminium (whether it be in fusion or not) only to metals which are themselves already in fusion. It is upon this latter principle that the following methods of manufacture are based.

1st. In an ordinary earthen crucible, containing gold in fusion, I add the alloy of aluminium and copper in calculated proportion, mix and cast in ingot.

2nd. To a mixture of gold and copper in fusion, I add the proper proportion of aluminium, mix and cast in ingot.

3rd. I first cast the gold in the form of a crucible which is then placed within an ordinary earthen crucible, and the whole heated. Before the gold begins to melt, I place in the gold-lined crucible the proper quantity of aluminium-copper alloy or a mixture, not yet melted together, of copper and aluminium. I complete the fusion of the whole mix, and cast in ingots.

This method should be followed in preparing the aluminium copper alloy, or equivalent precautions should be taken to avoid any chemical change in the aluminium in making the said alloy.

4th. In an ordinary earthen crucible I place gold and copper in calculated proportions, and as soon as these metals begin to melt, I place above this crucible iron, containing the proper proportion of aluminium, and having a hole in the bottom, so that as the aluminium melts it will fall into the molten mixture of gold and copper. This method may also be followed in preparing the aluminium copper alloy.

5th. The gold and copper are melted together in proper proportions in an ordinary earthen crucible and the aluminium in proper proportions is melted separately in an earthen or iron crucible and when all the metals are brought to a state of fusing, the aluminium is poured into the first crucible, mixed, and cast in ingots. This method may also be followed in preparing the aluminium copper alloy.

See 6,367 of 1886 on page 223.

See British Patent 21,170 of 1900, page 309.

22,264 of 1906, Hobson

This invention consists of the herein described improvements of gold alloys and the object of my invention is to

provide a gold alloy having decided advantages over the gold alloys in use at the present time. My gold alloys are very ductile, even more so than bronze, and are very easily worked in rolling, spinning and drawing processes and very useful for art metal work where a fine color of metal is required.

In producing gold alloys at the present time fine gold is melted with copper and silver, or with copper alone, or with silver alone, in certain proportions according to the number of carats fine and the color which the finished alloy is required to have.

According to my invention, I use zinc, manganese and copper in the gold alloy, either with fine gold alone, or with the addition of silver, or other metals, and I thus obtain a gold alloy which has many advantages over ordinary gold alloys, as my gold alloy has increased ductility, is harder and therefore wears longer than other gold alloys of the same degree of fineness, and moreover, it melts at a much higher temperature, and also a very wide range of color in the alloy can be attained independently of the fineness(so that it is possible to make, say, for instance, 12-carat gold, which will have the same color and appearance as 18-carat.

The proportions of the zinc and manganese which I use with copper alone, or with copper and other metals, in the compound base metal to form a gold alloy of any desired degree of fineness, depends chiefly upon the color required. I find the following gives very good results:

Zinc	from 19.5 parts to 22.5 parts
Manganese	from .5 parts to 2.5 parts
Copper	from 80.0 parts to 75.0 parts
	<hr/>
	100.0 100.0

My experiments show, however, that the proportion of zinc in the compound base metal to be alloyed with the fine gold should not exceed 40 parts, and that the proportion of the manganese should not exceed 10 parts, the bal-

ance, 50 parts, being made up of copper and any other suitable metals, such, for instance, as silver.

The proper proportions of this compound base metal are then alloyed with the proper proportions of fine gold to form the gold alloy of the number of carats fine required. The proportion of fine gold must never be less than one-fifth of the whole.

It will be understood that the darker colored alloys are obtained by increasing the proportion of the copper and decreasing the zinc and manganese, whereas by decreasing the proportion of the copper and increasing the zinc the color of the alloy will be lighter.

21.164 of 1912, Bloram

White gold alloys, soft enough for making ornaments (that is to say containing not less than 70 per cent. of gold), are made of gold and platinum with or without the addition of palladium and sometimes copper or silver. These are much too costly for practical use, since they must be sold at such a price as is equivalent to that of an ordinarily gold alloy of equal content of gold. Other white gold alloys such as gold-aluminium, gold-iron, gold-nickel, gold-tin, are too hard and brittle to be worked for making ornaments.

According to the present invention white gold alloys which are soft in the foregoing sense and fulfil in every respect the requirements of practice, can be made by substituting for the whole or a part of the metal of the platinum group (platinum, palladium), a metal of the iron nickel group, particularly nickel. In this manner alloys are obtained, the operation of manufacturing which is not substantially dearer than that of ordinary gold alloys, while on the other hand the brittleness produced by nickel alone is removed completely by the combination of nickel with the noble metal. Obviously, instead of pure gold, copper-gold alloys may be used as the starting material. In this case, however, the content of copper must not exceed

a certain limit, because an excess is attended by a passage of the desired white color into a reddish tint.

By correct choice of the proportions it is possible to obtain alloys which consist of gold, copper and nickel alone, without any other noble metal, and yet exhibit substantially the desired properties.

The composition of the alloy may vary within the limits. The metals to be added to the gold are best introduced as an alloy, the most advantageous composition for which is:

A metal or metals of the platinum group, 0.5 to 20 atoms per cent.

Copper, 4 to 30 atoms per cent.

Atoms per cent. are calculated by dividing the percentage by weight of each metal by the atomic weight of the metal to obtain the atomic ratio, which is then calculated to a percentage ratio; thus, if the atomic ratio is 1:4:5 the atomic per cent. are 10, 40 and 50.

This addition is considered as a whole, that is to say, if, for example, the alloy consist of x per cent. of gold and 100 minus x per cent. of the addition, the latter has the composition given above in atoms per cent.

U. S. PATENTS

CLASS 4-B

71,072, Schmitte & Levallois, Nov. 19, 1867

About 1,000 parts of pure copper, 700 of pure nickel and 50 of pure tungsten are first melted under charcoal, then granulated, and again melted with about 10 parts of pure aluminium, using borax and fluoride of calcium as a flux. The resulting alloy is comparable to silver, and may be forged, rolled, wire drawn, and annealed in the ordinary way.

99,007, Savage, Jan. 18, 1870

For producing alloys of manganese and copper with or without other metals, such as nickel, zinc, silver, or gold, to be employed as substitutes for German silver, black oxide of manganese is heated, with the other metals required to form the alloys, in the presence of solid, liquid, or gaseous carbonaceous substances, so that the other metals will melt with the manganese, when reduced to the metallic state. The pulverized oxide may be mixed with crushed charcoal and coal tar, and then placed with cyanide of potassium and the other metals in a crucible, into which a layer of charcoal is afterwards put, and it is then covered. The cyanide of potassium acts as a reducing agent, and protects the reduced manganese from oxidation.

See U. S. Patent 100,937 on page 8.

102,324, Savage, April 26, 1870

This is essentially the same as U. S. Patent No. 99,007. The cyanide of potassium is not used, but the crucibles

are heated in a reducing atmosphere as in a Siemens' furnace.

142,760, Pirsch-Baudoin, Sept. 16, 1873

The nature of said invention consists in the production of a metallic alloy resembling silver.

The following proportions are suitable, and produce a very white and silver-like metal:

Copper	71.00 parts.
Nickel	16.50 parts.
Cobalt	1.75 parts.
Tin	2.50 parts.
Iron	1.25 parts.
Zinc	7.00 parts.
<hr/>	
100.00	

In some cases, also, a small proportion—say, $\frac{1}{2}$ per cent.—of aluminium is added.

The nickel is first alloyed with an equal weight of copper, and the zinc also with copper in the proportion of six parts of the former to ten of the latter. The nickel alloy, the iron, the remainder of the copper, the cobalt (in the state of black oxide), and charcoal are then placed together in a plumbago crucible. The charge is covered with charcoal and the whole is exposed to a high heat. When the materials are melted the heat is reduced and the alloy of zinc and copper is added when the heat is such that it will just melt freely. This having been done, the crucible is taken from the fire and stirred with a rod of hazelwood. The tin is then added. It is wrapped in paper and dropped into the crucible. The metal is again stirred and at once cast into ingot moulds. It can afterward be rolled and otherwise worked as silver is worked.

Much of the zinc is volatilized in the process of melting, and the proportion ultimately remaining in the alloy is small.

The superiority of this alloy over other silver-like alloys depends mainly upon the influence of cobalt.

528,181, Roman, Oct. 30, 1894

Alloys are disclosed containing small proportions of copper, tin, antimony, tungsten, and about 98 per cent. of aluminium. Manganese or nickel may be substituted for the tin or antimony. Tungstic acid is reduced by fusing with an equivalent of cryolite and aluminium is added in such quantity as will produce a 10 per cent. alloy with the tungsten. An alloy of copper and aluminium is next produced, and the two alloys are then melted together, the other ingredients being added.

A suitable alloy is made up of the following: Copper, 0.375 per cent.; tin, 0.105 per cent.; antimony, 1.442 per cent.; tungsten, 0.038 per cent.; aluminium, 98.040 per cent.

This alloy is equal to aluminium in color, ductility, and resistance to oxidation, and may be rolled, forged, stamped, spun, turned, filed, etc

629,084, Mach, July 18, 1889

This invention relates to a new and improved alloy of aluminium and magnesium.

It has been demonstrated by numerous experiments that magnesium, with its lighter specific gravity (1.74), alloyed with aluminium in certain proportions gives the latter those qualities with respect to its mechanical working and strength which the pure aluminium does not possess. From these experiments it resulted that in order to produce the qualities mentioned as little as 10 and no more than 30 parts, by weight, of magnesium may be added to 100 parts of aluminium and that the proportion of 10 to 25 parts of magnesium to 100 parts of aluminium was the most advantageous.

If 100 parts of aluminium are alloyed with 10 parts of magnesium, the alloy has about the same mechanical quali-

ties as rolled zinc. An alloy of 100 parts of aluminium and 15 parts magnesium corresponds to good foundry brass, while an alloy of 100 parts of aluminium and of 20 parts of magnesium gives the metal the character of a softer red brass or a brass wire hard drawn, and, finally, an alloy of 25 parts of magnesium and 100 parts of aluminium represents the qualities of usual red brass.

The hardness and strength of the new alloy are so eminent that even axes, cock-pegs, etc., can be manufactured from it. The polish can be carried to brilliancy and is of an extraordinary resistance to the influence of the atmosphere. The color of the alloy is nearly silver white, differing from that of the pure aluminium, the color of which is somewhat unsightly.

808,453, Hobson, Dec. 26, 1905

Silver alloy consists of 92.5 per cent. of silver and 7.5 per cent. of manganese. Some of the manganese may be replaced by copper or brass or both. An extra quality alloy may contain a higher percentage of silver, the percentage of manganese being correspondingly reduced.

The new alloys are entirely free from fire scale and will withstand a much greater amount of heat.

See U. S. Patent 937,284 on page 165.

See U. S. Patent 937,285 on page 167.

1,099,561, McAdams, June 9, 1914

My invention consists in an alloy composed of aluminium, copper and silver in which the amount of aluminium exceeds the amount of copper and the amount of copper exceeds the amount of silver. More particularly, the aforesaid elements are preferably combined in the proportion of 100 parts by weight of aluminium, 5 parts by weight of copper and 2 parts by weight of silver.

In making the alloy, the aluminium is preferably first melted and the copper and silver introduced into the melt-

ed aluminium and the mass raised to such a degree as to melt the copper and silver, the melted mass being thoroughly agitated to bring the molecules of the different elements into intimate contact. The mass is then allowed to cool, and may then be rolled or tooled as may be desired. When rolled into a thin sheet, the alloy will present a brilliant white surface which will not tarnish; the sheet may be bent at pleasure, and will be so stiff and hard and at the same time resilient that the metal will keep the form into which it is bent without liability of becoming mashed out of shape. The small proportion of silver relative to the amount of copper and the small proportion of both silver and copper relative to the amount of aluminium makes the alloy almost as light as aluminium itself and adds but little to the cost of the alloy over the cost of aluminium alone.

I am aware that the elements, aluminium, copper and silver have heertofore been combined to form an alloy in which the silver exceeded the copper, but I believe that I am the first to succeed in producing a non-tarnishable, tough, resilient and stiff alloy capable of being rolled and worked like silver or copper by using an amount of silver so relatively small as compared with the amount of copper and aluminium.

I claim:

An aluminium alloy composed of aluminium, copper and silver combined substantially in the proportions of 100 parts aluminium, 5 parts copper and 2 parts silver.

1,104,369, McAdams, July 21, 1914

My invention consists of an alloy composed of tin, silver, cadmium and aluminium combined in substantially the following proportions, to wit: tin, 8 per cent. by weight; silver, 4 per cent. by weight; cadmium, 8 per cent. by weight; and aluminium, 80 per cent. by weight. In combining these substances to form the alloy, I first melt a

portion of the aluminium, for example, one-third, and raise it to such a temperature that the silver, when introduced, will readily combine with it. The silver is then introduced and after it has combined with this portion of the aluminium, the remainder of the aluminium is introduced into the mass, such introduction materially lowering the temperature of the mass. The cadmium is then introduced and then the tin, or the tin may be introduced and then the cadmium, the order of introduction of these two substances being a matter of choice or convenience. It is to be understood that the mass is to be thoroughly agitated when the different elements are introduced in order to make the mass homogeneous and thoroughly mix the substance being introduced throughout the mass into which it is introduced. The mass is then skimmed to remove any flux which may have been employed and then it may be poured to form ingots of any desired shape. These ingots are of a malleable nature and may be treated as a malleable metal and will have a brightness substantially like that of unoxidized silver. This metal will retain its luster and is proof against disintegration by nitric acid. It is extremely ductile and is amply strong for the manufacture of all silverware and may be furnished at a cost far below the cost of silver.

I claim :

An aluminium alloy composed of tin, silver, cadmium and aluminium in the proportions substantially as set forth.

BRITISH PATENTS

CLASS 4-B

2,285 of 1867

This corresponds to U. S. Patent 71,072 on page 286.

1,100 of 1870

This corresponds to U. S. Patent 99,007 on page 286.

1,075 of 1878, Clark

To make an alloy having the appearance and color of gold, I place in a crucible copper as pure as possible, platinum, and tungstic acid in the proportions below stated, and when the metals are completely melted I stir and granulate them by running them into water containing 500 grams of slaked lime and 500 grams of carbonate of potash for every cubic meter of water. This mixture dissolved in water has the property of rendering the alloy still purer. I then collect the granulated metal, dry it, and after having it remelted in a crucible I add a certain quantity of fine gold in the proportion hereinafter specified.

An alloy is thus provided, which, when run into ingots, presents the appearance of red gold of the standard 750/1000 and to which may be applied the name of "aphthite," or unalterable.

I may change the color of the alloy by varying the proportions of the different metals. As flux, I use boric acid, nitrate of soda, and chloride of sodium previously melted together in equal proportions. The proportion of flux to be employed is 25 grammes per kilogram of the alloy.

The following are the proportions I employ, by preference, for producing an alloy of red gold color:

Copper	800	grams
Platinum	25	"
Tungstic acid	10	"
Gold	170	"

To imitate silver or platinum I employ the following mixture of metals:

Iron	65	parts
Nickel	23	"
Tungsten	4	"
Aluminium	5	"
Copper	5	"

The iron and tungsten are melted together, and then granulated, as in the case of the previous alloy, except that in this instance the water into which the mixture is run contains one kilogram of slaked lime and one kilogram of carbonate of potash per cubic meter.

The nickel copper and aluminium are also melted together and granulated by running into water containing the same proportion of lime and potash.

Care should be taken during the melting to cover the metals contained in the two crucibles with a flux composed of 1 part of boric acid to 1 part of nitrate of potash or nitre.

In a the crucible containing the aluminium and copper, I place a lump of sodium of about 2 grams in weight when treating 5 kilograms of the three metals (nickel, copper and aluminium), together to prevent oxidation of the aluminium and I also add charcoal to prevent oxidation of the copper. Before granulating the metal in each crucible it should be well stirred, with a fire clay stirrer.

The granulated metals are dried as in the former case, when melted together, in the same crucible in the proportions above indicated, and well stirred after which the alloy is run into ingots.

The alloy thus obtained, to which may be given the name of "sideraphthite" (or unchangeable iron), presents the same white appearance as platinum or silver, and it is not more expensive than German silver.

These improved metallic alloys are capable of resisting the action of sulphuretted hydrogen, are unattacked by vegetable acids, and but slightly attacked by mineral acids, they are also perfectly ductile and malleable.

16,135 of 1891, Briggs

An alloy having a beautiful silver color, consists of 100 parts of aluminium, with from 1 to 49 parts of copper, nickel or tin, or a mixture of these metals. A light, strong, workable alloy consists of the following: 100 parts of aluminium with about 6 of copper, or $3\frac{1}{2}$ parts of nickel, or about 10 parts of tin. The alloy will not rust or become discolored.

4,460 of 1891

Alloys for the manufacture of surgical instruments, cutlery, spoons, jewelry, etc., consist of suitable proportions of iron or steel, tungsten, manganese, nickel, cadmium, and aluminium. They are non-oxidizing and will not rust. For spoons and jewelry the following is suitable: Aluminium, 4 oz.; nickel, 8 oz.; iron, 8 oz.; wolfram, 1 oz.; manganese, 2 oz. 399 grams; osmium, 1 grain.

19,545 of 1893

See U. S. Patent 528,181 on page 288.

14,502 of 1894, Dixon and Skinner

An alloy that will receive a higher polish than aluminium, and possesses greater ductility and strength, consists of aluminium about 96.25 parts, silver 3.5 parts, and copper 0.25 parts. This has a better color than aluminium and may be used for forks, spoons, etc.

16,033 of 1894, Ellis and Colbey

Alloys that possess great elasticity and will not corrode, are made up of 88 parts of aluminium, 9 of copper, and 4 of nickel, or of 88 parts of aluminium, $8\frac{1}{2}$ parts of copper, 2 parts of nickel, and $1\frac{1}{2}$ of zinc.

16,033A of 1894, Ellis and Colbey

A non-corrodible, strong and light alloy is composed of 88 parts of aluminium, 8 to 10 of copper, and 2 to 4 of nickel, $1\frac{1}{2}$ parts of zinc may be substituted for part of the nickel. This can be cast, rolled into sheets, drawn into tubes, and stamped.

21,186 of 1895, Roman

The alloy consists of aluminium and a small proportion of nickel and tungsten. It is prepared by either first preparing a nickel-tungsten alloy and adding aluminium, or by forming an aluminium tungsten alloy by reducing tungstic acid with cryolite and then adding aluminium and nickel to give the desired results. An alloy composed of 98 parts of aluminium, 1 part of nickel, and 1 part of tungsten, has all the properties of aluminium as far as regards weight, ductility, color and resistance to corrosion, is of greater tensile strength, has a far greater elasticity, can be more easily machined, and takes a finer polish.

21,575 of 1895, Partin

In order to increase the tenacity of aluminium it is alloyed with tungsten or magnesium. An alloy is first prepared by fusing together 78 parts of copper and 20 parts of tin, with the additional 2 parts of arsenate of potash. This alloy is crushed and mixed with 1 part of tungsten and 3 parts of antimony, and strongly heated in a brasqued crucible to effect fusion. The alloy so produced is added to the molten mass of aluminium. The resulting alloy is suitable for musical instruments. The mixture of tungsten

and antimony may be replaced by magnesia, tartrate of potash and chloride of sodium being used as fluxes.

6,991 of 1897, Griffith

Aluminium is strengthened by fusing in a crucible and adding a mixture of wolfram (tungsten ore) and borax. The metal is then stirred, and afterwards poured into the requisite moulds. The proportion of wolfram to the aluminium, varies from 5 to 20 grams to the kilogram, according to the intensity of resistance required from the metal.

6,729 of 1898, Roman

This discloses an alloy containing 60 parts of copper, 29 parts of nickel, 1 part of tungsten, and 10 parts of aluminium. The copper which forms 56 to 60 per cent. of the alloy, and the nickel, are first melted together and then the tungsten is introduced in aluminium cartridges. The metal is then shot into cold water, and is subsequently re-melted with a flux composed of borax and calcium fluoride and the aluminium is added. The alloy is white or silvery in color, and can be easily forged, rolled, or stamped at a bright red heat. It is not liable to rust or corrode.

22,073 of 1903, Green and Prescott

Alloys, consisting of about 70 to 90 parts of aluminium, 18 to 5 of magnesium, and 12 to 2 of cadmium, are used instead of electroplated ware, and for ornamental work, electric instruments, carriage fittings, bells, gongs, castings, etc. This alloy may be cast.

18,198 of 1909, Soc. Anon "Le ferro-nickel"

Aluminium alloys contain from 94 to 98 per cent. of aluminium, from 1.5 to 4 per cent. of copper, from 0.25 to 1.25 per cent. of silver. Specified alloys contain (1) 96.5 per cent. of aluminium, 1.875 per cent. of copper, 0.625 per cent. of manganese, and 1 per cent. of silver, and (2)

95.5 per cent. of aluminium, 3.5 per cent. of copper, 15 per cent. of manganese, and 15 per cent. of silver

These have great tensile strength and their color is whiter and more dazzling. They are ductile and malleable, and can be forged hot or cold.

See 8,270 of 1914 on page 229.

PREFACE TO CLASS 5

The properties of the alloys which are required in this connection are very similar to those required for Class 3. The British Patents show some valuable ideas which are not protected by corresponding U. S. Patents. For example, British Patent No. 9,050 of 1890 and No. 18,343 of 1890, give some carefully worked out formulæ for this purpose.

U. S. PATENTS

CLASS 5

16,784, Blandy, March 10, 1857

Alloys used for making plates for artificial teeth consist of 10 to 20 parts of tin, 1 to 5 of bismuth, 1 to 2 of antimony, and 1 to 2 of silver, with or without 5 to 15 parts of cadmium. Alloys containing 20 to 23 parts of tin, 4 to 6 of antimony, and 2 to 4, of silver, may be used. The bismuth and antimony neutralize the shrinkage on cooling of the other metals, and serve in conjunction with the silver and cadmium to give hardness, strength and rigidity to the alloy. The bismuth, tin and cadmium lower the melting point.

This alloy will not tarnish or corrode.

146,233, Conway, Jan. 6, 1874

The nature of my invention consists in purifying and fusing together the following named metals, in the following proportions and in the following manner, namely, platinum, gold, silver, bismuth, tin, and lead, viz., one scruple of platinum, one scruple of gold, one scruple of silver, 5 ounces of bismuth, 9 ounces of tin, and 2 of lead. All these metals should be perfectly pure. The bismuth, tin, and lead should be well refined before melting together. I melt each separately in a clean iron ladle, and, when melted, pour on a clean marble slab. I repeat the melting and pouring until there is no dross left of either the bismuth, tin, or lead. When this is done, I melt each separately again, and pour each separately into a clean glass dish

containing pure lemon juice. Repeat this last process three times, taking the cold metal from the acid and melting it again without washing. I then melt each of the three metals, bismuth, tin, and lead, again separately, and pour them on the marble slab, when they will be clean and pure from all impurities. I then take one scruple of platinum filings, one scruple of gold filings, and one scruple of silver filings; I put them in a clean iron ladle, and place upon them 5 ounces of bismuth thus purified and refined. I heat this till the whole mass becomes melted, shaking it gently. I then add 9 ounces of purified tin, and lastly, 2 ounces of lead; or those proportions of the six metals may be used. When the mass is well fused, I pour the whole mass upon a marble slab. This melting and pouring should be repeated twice, when the metal is finished by melting it and pouring it into an iron mould, forming it into an ingot. This forms an alloy easily fusible, tasteless, not deleterious to the health, and with which teeth-plates may be made and attached to the teeth permanently and effectually by simply melting the alloy and pouring it into a plaster cast, commonly used by dentists in vulcanizing a set of rubber teeth.

373,221, Carroll, Nov. 15, 1887

An object of my invention is to produce an alloy possessing lightness, stiffness, and strength, and capable of receiving a high polish, durable, and unoxidizable in the several uses for which it is designed.

In the employment of pure aluminium for the formation of crowns, bridges, or dental plates for the upper arch or jaw, where lightness of construction and specific gravity, as well as durability, are required, I have found by experiment that the tendency which said metal has to contract in cooling renders the casting of the said dentures at a single cast very unsatisfactory and partially impracticable and injurious to the mounted teeth.

To render the aluminium of practical value in casting and counteract its tendency to contract in cooling. I use

aluminium alloyed with silver and copper in such proportions to the aluminium as to counteract the contracting tendency of the aluminium, and thus establish an equilibrium of contraction and expansion in the alloy, which insures a perfect cast in the matrix which I desire to fill, thereby avoiding the fracture of any porcelain or artificial teeth that I may have mounted by the contraction of the pure aluminium if used alone. To overcome said difficulties and secure the valuable inherent properties of aluminium I find, after many experiments, that aluminium, silver, and copper combined in about the proportions hereinafter stated form an alloy possessing the properties and characteristics desired, although these proportions may be slightly varied and still subserve the same purpose, viz.: aluminium, 90 to 93 parts; silver, 5 to 9 parts; copper, 1 part.

617,359, Samsioe, Jan. 10, 1899

It has been customary to provide artificial teeth at the back with a plate of gold or platinum. It has been difficult, and in many cases impossible to secure an accurate fit. According to this invention a new alloy, by means of which a very accurate fit can be secured, is produced.

The said alloy consists of about 84 per cent. of tin, 15 per cent. of silver, $\frac{1}{2}$ per cent. of gold, and $\frac{1}{2}$ per cent. of platinum.

This alloy is used only in the form of pieces (as cubes or balls), and not in the finely divided or amalgamated state. It is fused over a Bunsen flame when used.

624,605, Allen, May 9, 1899

This invention contemplates the production of a new metallic compound or alloy for use in various arts where such a compound is desirable and where it can be advantageously employed.

One of the uses designed for the new compound or alloy is in connection with dental operations, the compound or

alloy to this end being possessed of advantages in the direction of lightness of weight, comparative great strength and rigidity, and is inexpensive, and is capable of being made into castings, such as dentures, which are free from flaws and other weakening defects.

The metallic compound or alloy consists of the following elements or ingredients, to wit: aluminium, platinum, and iridium. The relative proportions of these metals may vary as circumstances require; but I have found that the following proportions give good results: aluminium from 96 to 97 $\frac{7}{8}$ grains; platinum, from 2 to 3 grains; iridium, from $\frac{1}{8}$ to 2 grains.

The variation in the proportion of iridium is governed by requirements as to color and rigidity—as, for instance, if an alloy very light in color is desired $\frac{1}{8}$ of a grain of iridium will answer to give the proper result, whereas if a very hard and rigid alloy is demanded 1 to 2 grains of this metal is the proper proportion. In either event from 2 to 3 grains of platinum are employed, together with the stated proportion of aluminium.

The above-described metallic compound or alloy possesses advantages which render it especially valuable for use in making upper and lower complete and partial dentures, crowns, bridges, and the like employed in dentistry, for, in addition to its comparative lightness, great strength, and rigidity, it is practically non-corrosive and very durable. The elements or ingredients readily combine with each other and produce a compound which is low in fusion, thereby insuring economy both in the production of the compound and in the manufacture of the articles for which it is especially designed to be employed.

The presence of iridium in the relative proportion of from 1 to 2 grains gives to the compound or alloy a degree of hardness and rigidity approximating that of steel and steel alloys, and with this proportion of iridium present the compound or alloy may be employed to advantage in lieu of the metal and alloys named by reason of the addi-

tional quality of lightness and of being comparatively low in fusion and non-corrosive.

1,043,576, Eldred, Nov 5, 1912

Metals of the iron group can be united in an absolute and perfect manner with platinum, so that the joined metals can be worked by rolling, drawing, swaging, etc. This is done by assembling of a body of platinum which may be in the form of a tube, bar or plate in contact with the other metal and then cautiously raising the temperature of said other metal until the surface thereof is in superficial fusion with the production of a film of liquified metal. This film wets the surface of the platinum and enters into absolute molecular contact therewith.

Any convenient or controllable method of heating may be employed, but since it is desirable to produce a rapid rise in temperature, a flame fed with oxygen or enriched air is preferred. For making coated wire the platinum should be employed as a tube and the other metal as a closely fitting core. Where double-faced articles are desired, it is preferable to apply the two layers of platinum, one after the other.

For making pins, as anchors for artificial teeth, a core of nickel is desirable. For making leading-in wires for incandescent lamps, a core of nickel steel is preferable. For spark contact points, plugs and rivets, a foundation of nickel is used.

I claim:

1. The process of uniting platinum with stiff and strong metals which comprises assembling contacting bodies of platinum, and a stiff and strong metal, the contact being between major surfaces, raising the heat by heating through said platinum until said stiff and strong metal superficially liquefies and forms a wetting union with said platinum, and then quickly arresting said heating

See U. S. Patent 1,096,655 on page 187.

*1,107,180, Von Oefeke (Assigned one-half to Schweitzer),
Aug. 11, 1914*

This invention relates to alloys of vanadium, especially to that class in which the vanadium enters into combination with precious metals as for instance, gold, platinum, etc.

A further object of the invention is the process for the production of aforesaid alloys.

Heretofore alloys of iron, aluminium, copper and nickel with vanadium have become known and were used for various purposes in the trade. Alloys or mechanical combinations of vanadium and gold have heretofore never been made nor have they been described in any publication.

The alloy resulting from the process according to the present invention is much harder than any alloy of precious metals at present on the market and is therefore very well adapted for the use of dentists, etc., especially for coining purposes. Coins made of such an alloy are very well adapted to stand the wear to which gold coins for instance are daily subjected. They do not lose any of their value during their circulation and thus a considerable saving for the respective Governments is assured which is of the highest importance, especially in countries where gold coins are the chief means of exchange.

I include into my invention alloys of gold-alloys of any description with vanadium, alloys of vanadium-alloys of any description with gold, and also alloys of gold-alloys of any description with vanadium-alloys of any description.

Vanadium alloys especially considered in my invention are composed of vanadium with precious metals, such as gold, platinum, etc., and common metals, such as iron, aluminium, copper or nickel.

I claim:

1. As a new article an alloy of gold with a vanadium alloy.

2. As a new article an alloy of gold-vanadium with other metals.

3. As a new article an alloy of a gold combination with a vanadium alloy.

1,107,181, Von Oefele Aug. 11, 1914

I have described and claimed in my copending application for patent Serial No. 654,005, filed Oct. 11, 1911, as a new and useful article, alloys of vanadium alloys with gold. Aside of the ordinary way of producing such alloys by melting the metallic constituents, there are other ways of obtaining a metallic regulus of a gold vanadium alloy.

In my present application, I describe a method of producing vanadium gold alloys from vanadium compounds and gold preparations by using a chemical reducing agent as for example, carbon, and while I do not claim such method I consider the resulting alloy as the main object of my invention.

The process is as follows: Chemical compounds of vanadium, such as of vanadium and oxygen, vanadium and sulphur, or vanadium and chlorine are mixed with a gold preparation of either chemical or physical character both parts preferably in finest subdivision, a chemical reducing agent, for example, carbon is added and the whole subjected to heat. The regulus obtained from the chemical constituents represents a gold vanadium alloy which is obtained by a chemical reduction, taking place before and at the time of the alloy formation. The alloys produced by my said process possess very favorable properties in regard to strength and wear, and the described process affords the preparation of gold vanadium alloys with or without the presence of other metals according to the number and chemical relation of the mixed ingredients.

I claim :

As a new article, an alloy of vanadium with gold. .

*1,162,341, Coolidge (Assigned to General Electric Co.),
Nov. 30, 1915*

This relates to a composite body of tungsten or molybdenum joined to a layer of a gold-platinum alloys, for example, a rod or wire coated with gold-platinum alloy.

Gold containing about 1.5 per cent. of platinum is melted in an alumina crucible in a hydrogen atmosphere, and the tungsten or molybdenum is dipped into the molten alloy. The hydrogen prevents surface oxidation of the tungsten or molybdenum, but enables the gold alloy to wet or adhere to the surface of the refractory metal. Other alloying metals, as palladium, may also be added to the gold alloy to modify its hardness or melting point.

This coated article has the mechanical strength of tungsten or molybdenum and is incorrodible and may be soldered or joined to other metals. While especially useful in dentistry this new article may be used in the chemical industry or wherever a substantially incorrodible, strong, resilient metal article is desired.

I claim:

1. A composite metal article comprising tungsten and a coating comprising an alloy of gold and platinum mechanically united to or wetting said tungsten.

See U. S. Patent 1,169,753 on page 277.

See U. S. Patent 1,229,960 on page 51.

See U. S. Patent 1,236,384 on page 55.

1,252,038, Sandell (Assigned to Mills), Jan. 1, 1918

My invention relates to improvements in alloys particularly to an alloy especially designed as a substitute for platinum in the dental arts as, for example, for use as a rivet for fillings in false teeth.

My new alloy is prepared in the following manner:

Ten parts by weight of tungsten is melted in an electric arc and to the molten mass there is added 7 parts by weight

of nickel and 3 parts by weight of powdered graphitic carbon. This mixture or alloy is permitted to set, remelted in an electric furnace and to it there is added 80 parts by weight of commercial gold as, for example, 18 carat gold. The alloy is now complete.

The melting point of this alloy is apparently about the same as that of platinum. Its tensile strength is high, it is malleable to such an extent as to make it adapted for most purposes, particularly in the dental art, for which platinum is now used, and it is not attacked by mineral acids.

I claim:

1. An alloy comprising 80 parts by weight of gold, 10 parts by weight of tungsten, 7 parts by weight of nickel and a relatively small proportion of carbon.

2. The method of alloying gold with tungsten and a lower melting-point metal which comprises, first, preparing an alloy of the tungsten and lower melting-point metal in an electric arc, and subsequently alloying such primary alloy with gold.

BRITISH PATENTS

CLASS 5.

1,232 of 1857

This corresponds to U. S. Patent 16,784 on page 299.

9,050 of 1890, Potter

The pins of artificial porcelain teeth are made of an alloy of gold which will withstand the intense heat necessary in baking the teeth. A suitable alloy is composed of 16 parts of gold, 6 parts of silver, and 2 parts of platinum. Another alloy is composed of 16 parts of gold, 5 parts of silver, 2 parts of copper, and 1 part of platinum. These alloys can take the place of pure platinum.

18,343 of 1890, Marston

Pins or other attachments for artificial teeth are made of an alloy having a melting point at or below that of an alloy of 6 parts of platinum and 4 parts of nickel. Several alloys containing two or more of the following metals, namely: platinum, gold, iridium, palladium, silver, aluminium, copper, nickel, and iron, are enumerated in the specification. Rhodium and osmium may also be used as well as ruthenium, zinc, tin, cadmium, manganese, cobalt or nickel.

Some of the alloys are as follows: 1 part of platinum, 2 parts of silver; 1 part of palladium, 3 parts of silver; 6 parts of gold, 1 part of palladium, 18 parts of gold. 2 parts of palladium, 1 of silver; 2 to 4 parts of palladium; 1 of nickel; 1 part of palladium, 1 to 5 parts of nickel.

7,435 of 1898, Gartrell

A dental plate is made up of two plates united together by heat and pressure, one of fine gold and the other of an alloy of 90 parts of silver and 10 parts of platinum. The alloy of silver and platinum prevents the silver from becoming changed to silver sulphide during the vulcanizing of the rubber. A thick plate is made of the silver-platinum alloy and this is united to a plate of fine gold by heat and pressure. The two plates are placed together and heated to redness, pressure is then applied with a hydraulic press, and the combined piece of metal is afterwards rolled in a mill to the gauge desired.

9,069, Samsioe, 1898

This corresponds to U. S. Patent 617,359 on page 301.

21,170, Marston, 1900

This invention has for its object the manufacture of teeth-adjuncts and metal dentures composed of alloys which are capable of withstanding without injury the common treatment to which mineral teeth, and metal dentures are subjected in different processes of their manufacture, and afterwards in wear as substitutes for the natural organs of mastication. By a long series of experiments I have discovered the practical fitness possessed in alloys composed of gold and silver in variable proportions for furnishing mineral teeth with all kinds of pins, strips, loops, and other forms of anchorage for securing them in their proper places on their frames or plates which combined constitute partial or complete dentures. I am aware that all alloys of gold and silver have already been and are now being used for making dental plates; but all those alloys have always contained copper or other oxidizable metal and for that reason could never be used for providing mineral teeth with pins or other forms of anchorage. All gold alloys which have been used for making dental

plates, but which, however, could never be used in the making of pins and other forms of anchorage for mineral teeth, but have always resembled gold in color and it is commonly known that copper has always been used for imparting richness of color to alloys that are poor in gold, on the other hand alloys of gold and silver which I use for the purpose hereinbefore specified are distinguishable from ordinary gold alloys by the whiteness or comparative whiteness of their color. Now, whereas, no white gold alloy has ever heretofore been used for making dental plates both the combination of these two metals, and its application to the purpose of my invention are alike. I am also aware that other persons have from time to time tried to terminate the necessity of using platinum in the making of pins or other adjuncts for mineral teeth, but all the alloys which those persons endeavored to use contained either methods which become oxidized by the action of air upon them at high temperatures or else the preparation of platinum, or some platinoid metal equally capable of causing brittleness, and other defectiveness rather than have unworkable and absolutely useless for that purpose. For this reason platinum tins have never been supplanted in the manufacture of mineral teeth. My discovery of the peculiar ductility, malleability, tensile strength, indifference to oxygen at high temperature, inertness, and permanency in wire possessed by the aforesaid alloys of gold and silver and my subsequent experimental application to them, to the purpose hereinbefore mentioned, proved that the necessity of using platinum for furnishing mineral teeth with pins and other adjuncts, and for making metal dentures now no longer exists. From what has already been said it is apparent that an addition of any metal which oxidizes when heated at high temperatures or of platinum, or any platinoid metal is positively injurious to the peculiar properties possessed by the combinations of gold and silver and which properties are essential purpose of my invention. Pins, tubes, strips, loops, and other forms of anchorage, are preferably mould-

ed in the pasty raw teeth material during the portion of moulding the teeth, but they may be inserted in previously baked teeth by placing them in suitable cavities made for them and be securely fixed therein by the fusion or the condensation of any suitable metallic or non-metallic substance. For dental plates the gold and silver alloy is rolled into sheets and is made up by any of the methods used for making such appliances. I vary the proportions in which the gold and silver are presented to each other, according to the price paid for the mineral teeth the dentures or the metal, whichever are wanted. My invention comprises all preparations of gold and silver ranging from 10 per cent. of gold to 90 per cent. of silver, and from 10 per cent. of silver to 90 per cent. of gold.

22,237 of 1908, Siemens & Halske Aktiengesellschaft.

It has already been suggested that the supports, such as pins, claws or the like, for affixing artificial teeth to the natural root or to artificial carriers or mouth-plates should be made of tantalum or an alloy thereof.

Pure tantalum and many alloys thereof have, however, a disadvantage that they possess very great affinity for most other materials when they are heated to a high temperature. For this reason it is extremely difficult to work this metal in the usual manner and to burn it into the artificial teeth in the furnaces generally employed.

According to the present invention in order to remove these disadvantages an alloy of nickel and tungsten is used for making these supports. A most suitable alloy has been found to consist of about 8 to 15 per cent. of nickel, for example, an alloy containing 10 per cent. of nickel shows a very high degree of ductility and possesses nearly all the good properties of tantalum; moreover it can be burnt comparatively easily into the artificial teeth in the furnaces.

The present invention comprises a metal body consisting of tungsten or molybdenum and a layer of precious metal intimately united therewith which is useful for various purposes in the arts, as, for example, in dentistry.

Dental crowns and bridges require pins or posts of incorrodible metal, having good mechanical strength. Formerly, platinum-irridium alloy has been used for this purpose, but this alloy is very expensive and is softened at temperatures to which it must necessarily be subjected during the production of the completed crown.

Tungsten and molybdenum in the ductile state possess the desired mechanical properties and will retain these properties even at relatively high temperatures. These metals although substantially incorrodible are not wet by gold, even when care is exercised to prevent oxidation, and hence difficulty is experienced in casting gold crowns against stems or posts of tungsten or molybdenum, or otherwise joining gold thereto.

We have discovered that when a small amount of platinum is alloyed with gold, the tungsten or molybdenum is wet by the molten alloy in an atmosphere of hydrogen and a firm union is produced.

Our invention comprises a composite body consisting of tungsten or molybdenum joined to a layer of a gold-platinum alloy as, for example, a rod or wire coated with gold-platinum alloy. The invention also comprises the method of coating an article of tungsten or molybdenum with an alloy containing gold and platinum, which consists in dipping the article in the molten alloy in an atmosphere of hydrogen.

This new article of metal may be produced by melting gold containing about 1.5 per cent. of platinum in an alumina crucible in a hydrogen atmosphere and dipping the tungsten or molybdenum, for example, in the form of a rod or wire of ductile metal into the molten alloy. A

thin layer of gold platinum alloy will unite firmly with the tungsten or molybdenum. The hydrogen not only prevents surface oxidation of the tungsten or molybdenum, but also enables the gold alloy to wet or adhere to the surface of the refractory metal. Other alloying metals, such, for example, as palladium, may also be added to the gold alloy to modify its melting point or its hardness.

The gold coated metal article is cheaper than platinum-iridium, as the mechanical strength of tungsten or molybdenum, and the gold coated surface is not only incorrodible, but may readily be soldered or otherwise joined to other metals. The good mechanical properties of tungsten or molybdenum, particularly toughness and springiness, are not lost at the high temperatures necessary for casting or soldering operations, say about 1000° to 1100° C.

While especially useful in dentistry this new metal article is not limited to this particular field. It may be used in the chemical industry or wherever substantially incorrodible, strong, resilient metal article is desired.

104,025, Jackson, April 25, 1917

An alloy, particularly for pins for artificial teeth, consists of platinum, palladium, and gold, the palladium and gold together being greatly in excess of the platinum, which is itself present in sufficient quantity to raise the melting point of the alloy above that of porcelain. The alloy may contain 15 to 20 parts of platinum, 30 to 35 parts of palladium, and 45 to 55 parts of gold; or these proportions may be slightly varied. Iridium, preferably not exceeding 2 per cent., or a small proportion of osmium, ruthenium or rhodium may be added.

ERRATUM.

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